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16. ABSTRACT

→ Th~~is~~e report presents national and regional trends in air quality from 1980 through 1989 for total suspended particulate, sulfur dioxide, carbon monoxide, nitrogen dioxide, ozone and lead. Air quality trends are also presented for 14 metropolitan areas. Both national and regional trends in each of these pollutants are examined. National air quality trends are also presented for both the National Air Monitoring Sites (NAMS) and other site categories. In addition to ambient air quality, trends are also presented for annual nationwide emissions. These emissions are estimated using the best available engineering calculations; the ambient levels presented are averages of direct measurements.

This report also includes a section, Air Quality Levels in Metropolitan Statistical Areas (MSAs). Its purpose is to provide interested members of the air pollution control community, the private sector and the general public with greatly simplified air pollution information. Air quality statistics are presented for each of the pollutants for all MSAs with data in 1989. ←

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Air Pollution Trends Emission Trends Carbon Monoxide Nitrogen Dioxide Ozone Sulfur Dioxide Total Suspended Particulates Lead	Air Pollution Metropolitan Statistical Area (MSA) Air Quality Standards National Air Monitoring Stations (NAMS)		

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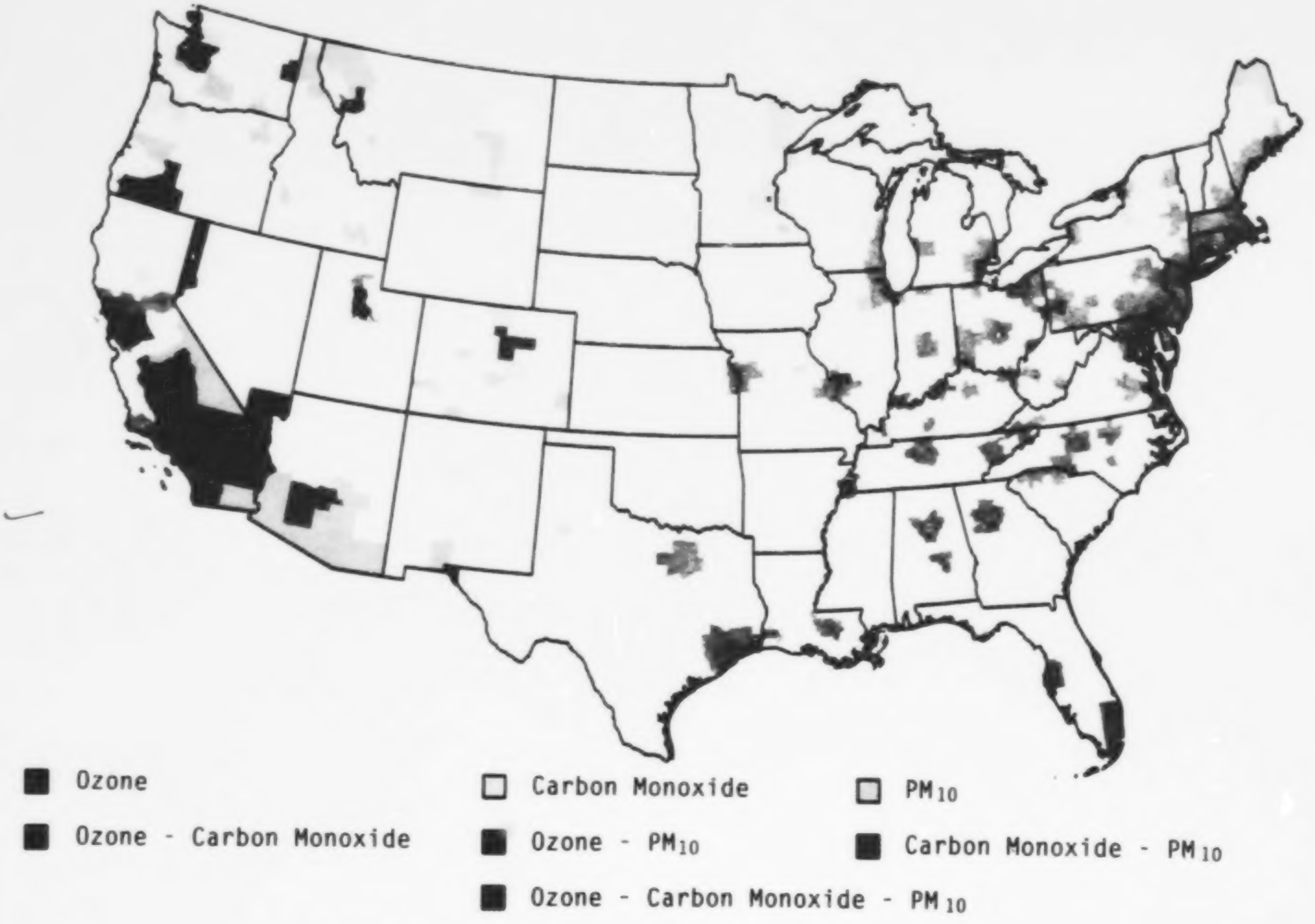
■ Ozone
■ Ozone - Carbon Monoxide
☐ Carbon Monoxide
■ Ozone - PM10
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☐ PM10
■ Carbon Monoxide - PM10

Areas Not Meeting Ozone, CO or PM_{10} NAAQS

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National Air Quality and Emissions Trends Report, 1989

Technical Support Division

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Radiation
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711
February 1991

DISCLAIMER

This report has been reviewed by the Office of Air Quality Planning and Standards, U. S. Environmental Protection Agency, and has been approved for publication. Mention of trade names or commercial products is not intended to constitute endorsement or recommendation for use.

About the Cover: The map displays those counties within the contiguous U.S. that contain areas not meeting ozone, carbon monoxide and/or particulate matter National Ambient Air Quality Standards (NAAQS). See Section 4 for information on these areas.

PREFACE

This is the seventeenth annual report of air pollution trends issued by the U. S. Environmental Protection Agency. The report is prepared by the Technical Support Division and is directed toward both the technical air pollution audience and the interested general public. The Division solicits comments on this report and welcomes suggestions on our trend techniques, interpretations, conclusions, and methods of presentation. Please forward any response to Dr. Thomas C. Curran, (MD-14) U. S. Environmental Protection Agency, Technical Support Division, Research Triangle Park, North Carolina 27711.

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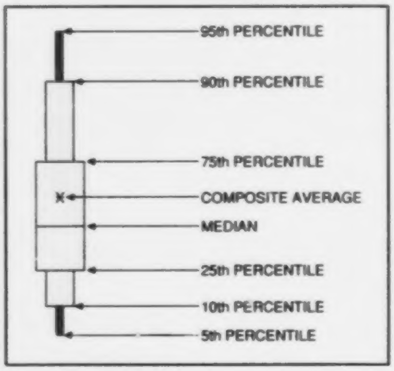
NATIONAL AIR QUALITY AND EMISSIONS TRENDS REPORT, 1989

1. EXECUTIVE SUMMARY

1.1 INTRODUCTION

This is the seventeenth annual report[1-16] documenting air pollution trends in the United States for those pollutants that have National Ambient Air Quality Standards (NAAQS). These standards have been promulgated by the U. S. Environmental Protection Agency (EPA) to protect public health and welfare. There are two types of NAAQS, primary and secondary. Primary standards are designed to protect public health, while secondary standards protect public welfare, including effects of air pollution on vegetation, materials and visibility. This report focuses on comparisons with the primary standards in effect in 1989 to examine changes in air pollution levels over time, and to summarize current air pollution status. There are six pollutants that have NAAQS: particulate matter (formerly as total suspended particulate (TSP) and now as PM_{10} which emphasizes the smaller particles), sulfur dioxide (SO_2), carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3) and lead (Pb). It is important to note that the discussions of ozone in this report refer to ground level, or tropospheric, ozone and not to stratospheric ozone. Ozone in the stratosphere, miles above the earth, is a beneficial screen from the sun's ultraviolet rays. Ozone at ground level, in the air we breathe, is a health and environmental concern.



The trends in ambient air quality that follow are presented as boxplots, which display the 5th, 10th, 25th, 50th (median), 75th, 90th and 95th percentiles of the data, as well as the composite average. The 5th, 10th and 25th percentiles depict the "cleaner" sites, while the 75th, 90th and 95th depict the "higher" sites and the median and average describe the "typical" sites. For example, the 90th percentile means that 90 percent of the sites had concentrations less than or equal to that value, and only 10 percent of the sites had concentrations that were higher. Boxplots simultaneously illustrate trends in the "cleaner", "typical" and "higher" sites.

The ambient air quality trends presented in this report are based upon actual direct measurements. These air quality trends are supplemented with trends for nationwide emissions, which are based upon the best available engineering calculations. Chapter 4 of this report includes a detailed listing of selected 1989 air quality summary statistics for every metropolitan statistical area (MSA) in the nation and maps highlighting the largest MSAs. Chapter 5 presents 1980-89 trends for 14 cities.

PARTICULATE MATTER

AIR QUALITY

Total Suspended Particulates (TSP)
1982-89*: geometric mean: 1 percent decrease (1648 sites)
1988-89: geometric mean: 5 percent decrease (1014 sites)
* 8-year period (see comments)

PM_{10}
1988-89: arithmetic mean: 3 percent decrease (357 sites)

EMISSIONS

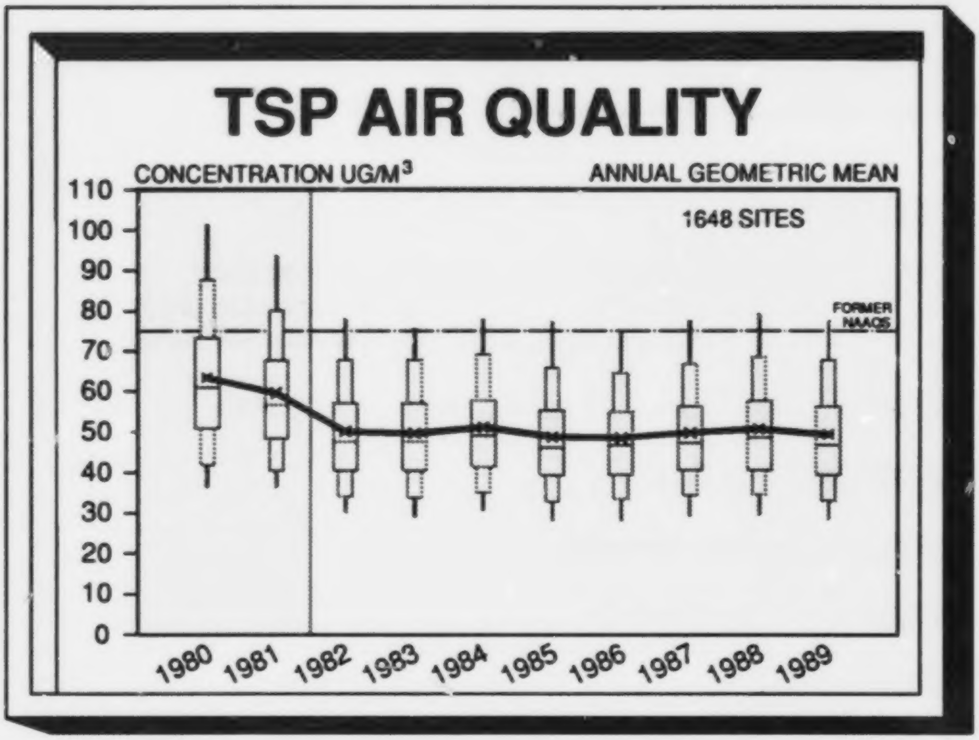
1982-89: 1 percent increase **(TSP)**
(Note: 10-year 1980-89 change was 15 percent decrease)
1988-89: 4 percent decrease **(TSP)**; 3 percent decrease **(PM_{10})**

COMMENTS

The 1980-81 TSP data were affected by a change in sampling filters, therefore, these years are shaded to indicate the uncertainty in the TSP measurements. The highest average and peak 24-hour PM_{10} concentrations are seen in Regions IX and X. The 1988 TSP and PM_{10} air quality levels were affected by generally drier conditions and higher than normal forest fire activity.

PM EFFECTS

Based on studies of human populations exposed to high concentrations of particles (often in the presence of sulfur dioxide), and laboratory studies of animals and humans, the major effects of concern for human health include effects on breathing and respiratory symptoms, aggravation of existing respiratory and cardiovascular disease, alterations in the body's defense systems against foreign materials, damage to lung tissues, carcinogenesis, and premature mortality. The major subgroups of the population that appear likely to be most sensitive to the effects of particulate matter include individuals with chronic obstructive pulmonary or cardiovascular disease, individuals with influenza, asthmatics, the elderly, and children. Particulate matter causes material soiling and is responsible for substantial visibility impairment in many parts of the U.S.



WORTH NOTING

The PM_{10} NAAQS replaced EPA's earlier TSP standard in 1987. PM_{10} focuses on those particles with aerodynamic diameters smaller than 10 micrometers, which are likely to be responsible for adverse health effects because of their ability to reach the lower regions of the respiratory tract. PM_{10} appears to represent essentially all of the particulate emissions from transportation sources and most of the emissions in the other traditional categories. However, fugitive PM_{10} emissions are 8 times more than the total of all traditional particulate matter sources categories.

SULFUR DIOXIDE (SO_2)

AIR QUALITY

1980-89: arithmetic mean: 24 percent decrease (409 sites)
24-hour second high: 26 percent decrease (405 sites)
24-hour exceedances: 95 percent decrease (405 sites)

1988-89: arithmetic mean: 3 percent decrease (513 sites)

EMISSIONS (SOx)

1980-89: 10 percent decrease

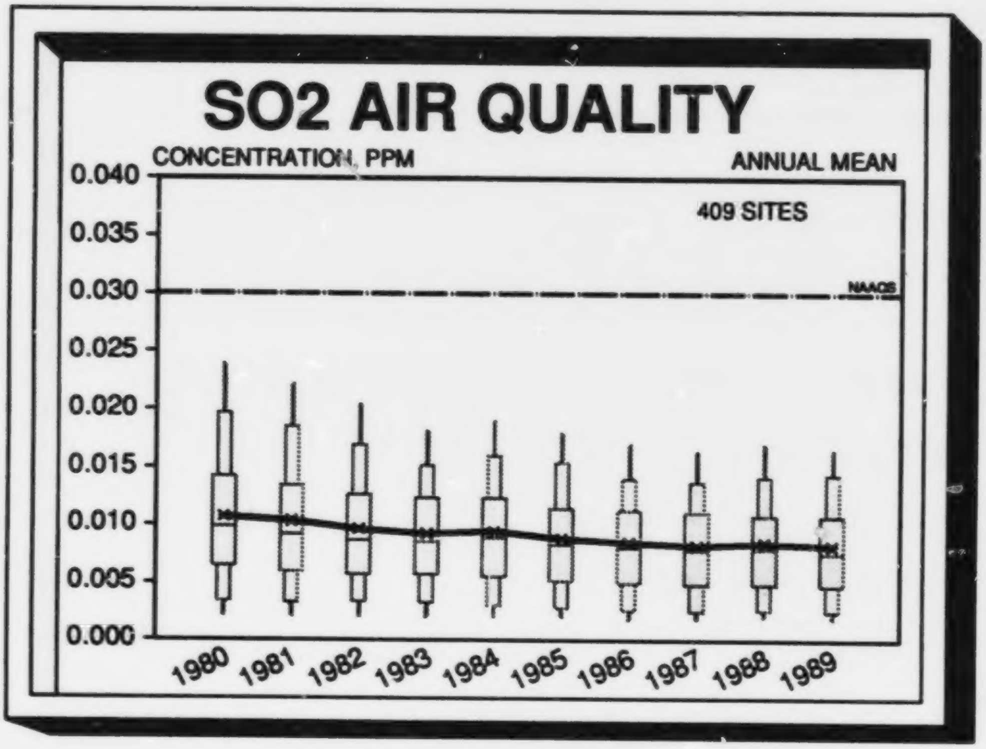
1988-89: 1 percent increase

COMMENTS

The vast majority of SO_2 monitoring sites do not show any exceedances of the 24-hour NAAQS and the exceedance trend is dominated by source oriented sites. The decrease in sulfur oxides emissions from 1980 to 1989 reflects reductions at coal-fired power plants. The increase in sulfur oxides emissions between 1988 and 1989 is due to increased emissions from fuel combustion. The difference between the air quality trends and the emission trends result from the historical ambient monitoring networks being population-oriented while the major emission sources tend to be in less populated areas.

SO_2 EFFECTS

The major health effects of concern associated with high exposures to SO_2 include effects on breathing, respiratory illness and symptoms, alterations in the lung's defenses, aggravation of existing respiratory and cardiovascular disease, and mortality. The major subgroups of the population most sensitive to SO_2 include asthmatics and individuals with chronic lung disease (such as bronchitis or emphysema) or cardiovascular disease. Children and the elderly may also be sensitive. Sulfur dioxide produces foliar damage on trees and agriculture crops and acts as a precursor to acidic precipitation.



WORTH NOTING

Almost all monitors in U.S. urban areas meet EPA's ambient SO_2 standards, which apply to ground level concentrations. Most ambient SO_2 monitors are population oriented rather than source oriented. Dispersion models are commonly used to assess ambient SO_2 problems around point sources because it is frequently impractical to operate enough monitors to provide a complete air quality assessment. Current concerns about sulfur dioxide focus on major emitters, total atmospheric loadings, and the possible need for a shorter-term (i.e. 1-hour) standard. Two-thirds of all national SO_x emissions are generated by electric utilities (95 percent of which come from coal fired power plants). The majority of these emissions, however, are produced by a small number of facilities. Fifty individual plants in 15 states account for one-half of all power plant emissions.

CARBON MONOXIDE (CO)

AIR QUALITY

1980-89: 8-hour second high: 25 percent decrease (280 sites)
8-hour exceedances: 80 percent decrease (280 sites)

1988-89: 8-hour second high: 1 percent decrease (355 sites)

EMISSIONS

1980-89: 23 percent decrease

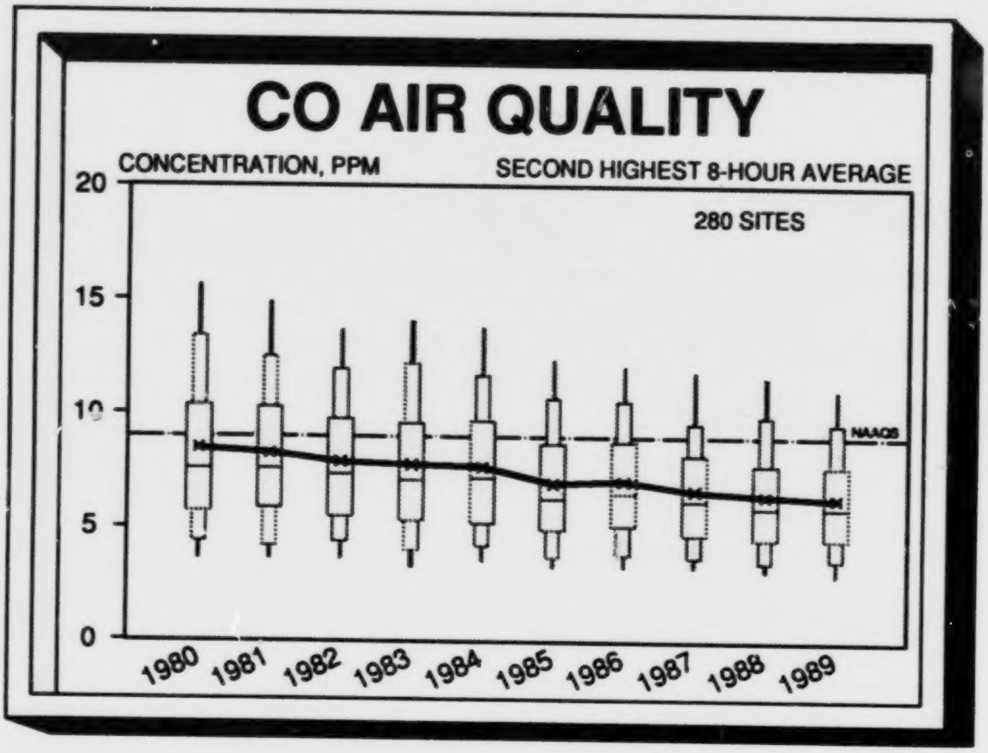
1988-89: 6 percent decrease

COMMENTS

While there is general agreement between the air quality and emission changes over this 10-year period, it should be recognized that the emission changes reflect estimated national totals while the ambient CO monitors are frequently located to identify problems. The mix of vehicles and the change in vehicle miles of travel in an area around a typical CO monitoring site may differ from the national averages.

CO EFFECTS

Carbon monoxide enters the bloodstream and disrupts the delivery of oxygen to the body's organs and tissues. The health threat from carbon monoxide is serious for those who suffer from cardiovascular disease, particularly those with angina or peripheral vascular disease. Healthy individuals also are affected. Exposure to elevated carbon monoxide levels is associated with impairment of visual perception, manual dexterity, learning ability and performance of complex tasks.



WORTH NOTING

Transportation sources account for approximately two-thirds of the nation's CO emissions. Emissions from highway vehicles decreased 33 percent during the 1980-89 period, despite a 39 percent increase in vehicle miles of travel. Estimated nationwide CO emissions decreased 6 percent between 1988 and 1989, due mostly to decreased forest fire activity in 1989. CO emissions from highway vehicles decreased 4 percent between 1988 and 1989.

The most recent assessment of the CO problem in the U.S. found 41 areas failing to meet the CO NAAQS in 1988-89. This is three fewer areas than for the 1987-88 time period.

NITROGEN DIOXIDE (NO_2)

AIR QUALITY

1980-89: annual mean: 5 percent decrease (148 sites)

1988-89: annual mean: 2 percent decrease (200 sites)

EMISSIONS (NOx)

1980-89: 5 percent decrease

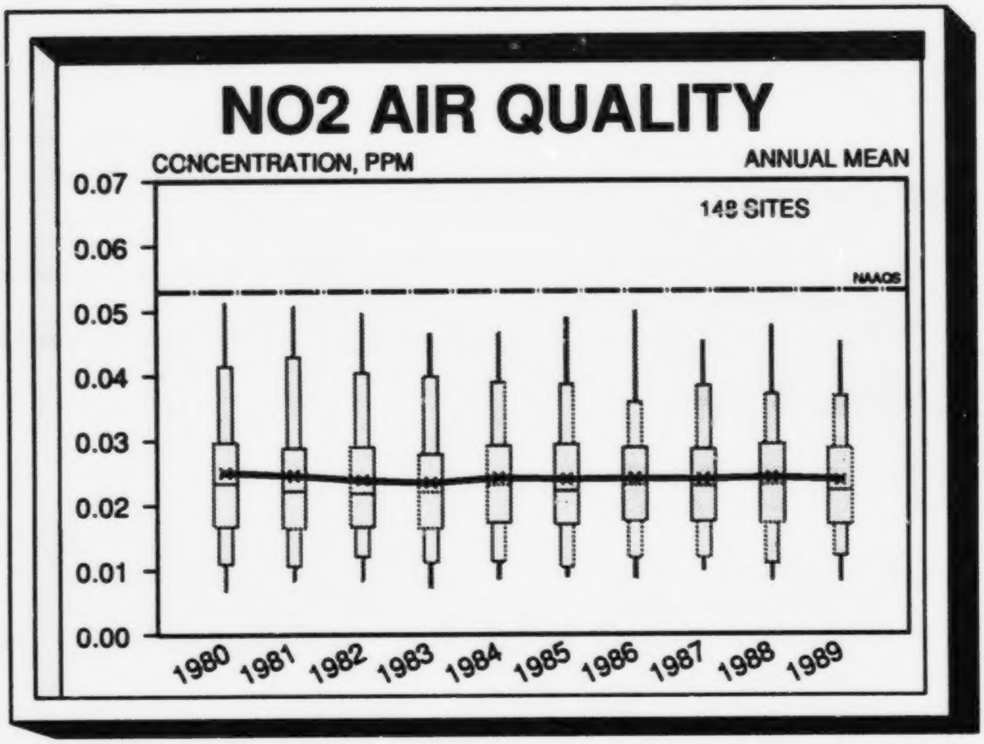
1988-89: 1 percent decrease

COMMENTS

The national trend in annual mean NO_2 concentrations in the late 1980's continues to be flat. The two primary source categories of nitrogen oxide emissions, and their contribution in 1989, are fuel combustion (56 percent) and transportation (40 percent).

NO_2 EFFECTS

Nitrogen oxides can irritate the lungs and lower resistance to respiratory infections such as influenza. The effects of short-term exposures are still under study, but continued or frequent exposure to concentrations higher than those normally found in the ambient air can cause pulmonary edema. Nitrogen dioxide acts as a precursor to acidic precipitation and plays a key role in nitrogen loading of forests and ecosystems.



WORTH NOTING

Los Angeles, CA, which reported an annual mean of 0.057 ppm in 1989, is the only urban area that has recorded violations of the annual NO_2 NAAQS of 0.053 ppm during the past 10 years.

OZONE (O_3)

AIR QUALITY

1980-89: second highest daily max 1-hour: 14 percent decrease (431 sites)
exceedance days: 53 percent decrease
1988-89: second highest daily max 1-hour: 15 percent decrease (581 sites)

EMISSIONS (VOC)

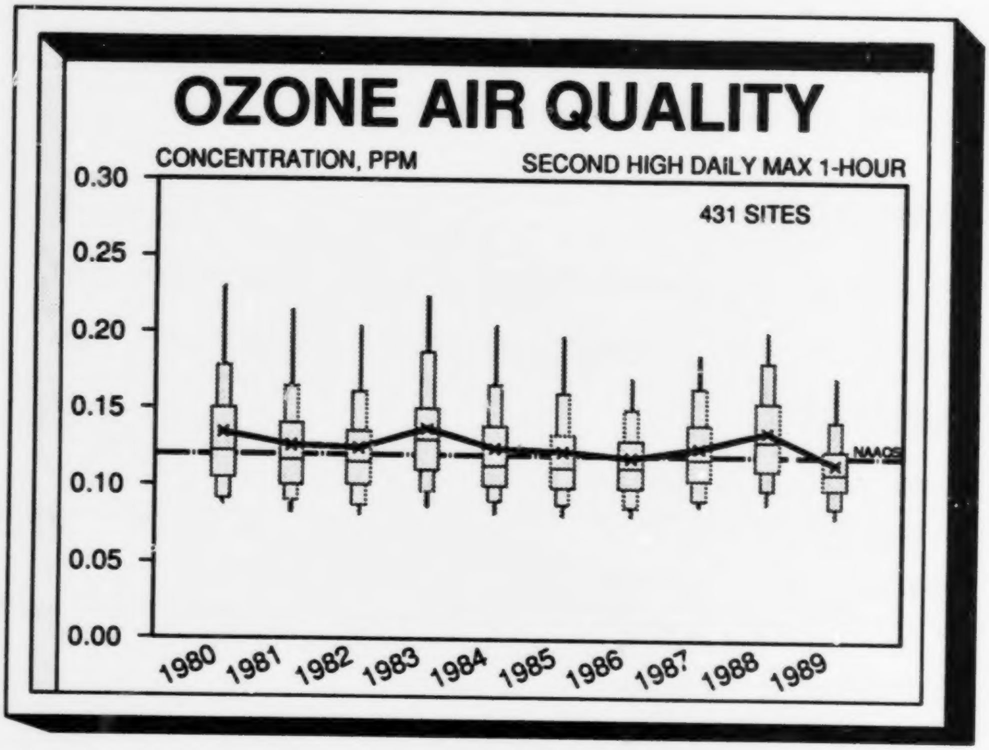
1980-89: 19 percent decrease
1988-89: 5 percent decrease

COMMENTS

The volatile organic compound (VOC) emission estimates represent annual totals. While these are the best national numbers now available, ozone is predominantly a warm weather problem and seasonal emission trends would be preferable. Previously, VOC emissions from highway vehicles were estimated using nationwide annual temperatures and nationwide average Reid Vapor Pressure (RVP). This year's estimates are based on statewide average monthly temperatures and statewide RVP. NO_x emissions, another factor in ozone formation, decreased 5 percent between 1980 and 1989.

O_3 EFFECTS

The reactivity of ozone causes health problems because it tends to break down biological tissues and cells. Recent scientific evidence indicates that high levels of ozone not only affect people with impaired respiratory systems, such as asthmatics, but healthy adults and children, as well. Exposure to ozone for only several hours at relatively low concentrations has been found to significantly reduce lung function in normal, healthy people during periods of exercise. This decrease in lung function generally is accompanied by symptoms including chest pain, coughing, sneezing and pulmonary congestion. Though less well established in humans, animal studies have demonstrated that repeated exposure to ozone for months to years can produce permanent structural damage in the lungs and accelerate the rate of lung function loss. Ozone is responsible each year for agricultural crop yield loss in the U.S. of several billion dollars and causes noticeable foliar damage in many crops and species of trees. Forest and ecosystem damage may result from high ambient ozone levels.



WORTH NOTING

The relatively high ozone concentrations in both 1983 and 1988 are likely attributed in part to hot, dry, stagnant conditions in some areas of the country that were more conducive to ozone formation than other years. Meteorological conditions in the summer of 1989 were less conducive to ozone formation than 1983 and 1988. Between 1980 and 1989, VOC emissions from highway vehicles are estimated to have decreased 34 percent, despite a 39 percent increase in vehicle miles of travel during this time period. Nationwide VOC emissions decreased 5 percent between 1988 and 1989 due to the ongoing Federal Motor Vehicle Control Program (FMVCP) and new measures to lower Reid Vapor Pressure (RVP) in gasoline. Preliminary 1990 data indicate that ozone levels are likely to be slightly lower than those in 1989.

LEAD (Pb)

AIR QUALITY

1980-89: maximum quarterly average: 87 percent decrease (189 sites)

1988-89: maximum quarterly average: 14 percent decrease (245 sites)

EMISSIONS

1980-89: 90 percent decrease in total lead emissions
(96 percent decrease in lead emissions from transportation sources)

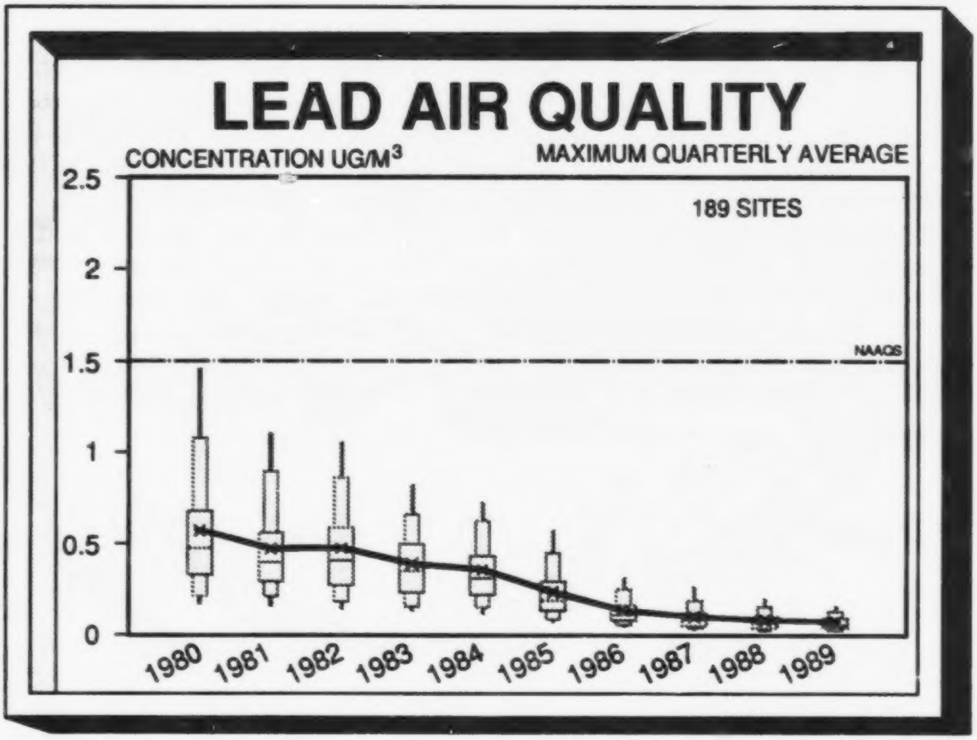
1988-89: 5 percent decrease in total lead emissions
(15 percent decrease in lead emissions from transportation sources)

COMMENTS

The ambient lead trends presented here primarily represent general urban conditions predominantly reflecting automotive sources. Ambient trends are also presented for a small number of lead monitoring sites (19) in the vicinity of point sources of lead such as primary and secondary lead smelters.

LEAD EFFECTS

Exposure to lead can occur through multiple pathways, including air, diet and ingestion of lead in soil and dust. Lead accumulates in the body in blood, bone, and soft tissue. Because it is not readily excreted, lead also affects the kidneys, nervous system, and blood-forming organs. Excessive exposure to lead may cause neurological impairments such as seizures, mental retardation, and/or behavioral disorders. Even at low doses, lead exposure is associated with changes in fundamental enzymatic, energy transfer and homeostatic mechanisms in the body. Infants and children are especially susceptible to low doses of lead, often suffering central nervous system damage. Recent studies have also shown that lead may be a factor in high blood pressure and subsequent heart disease.

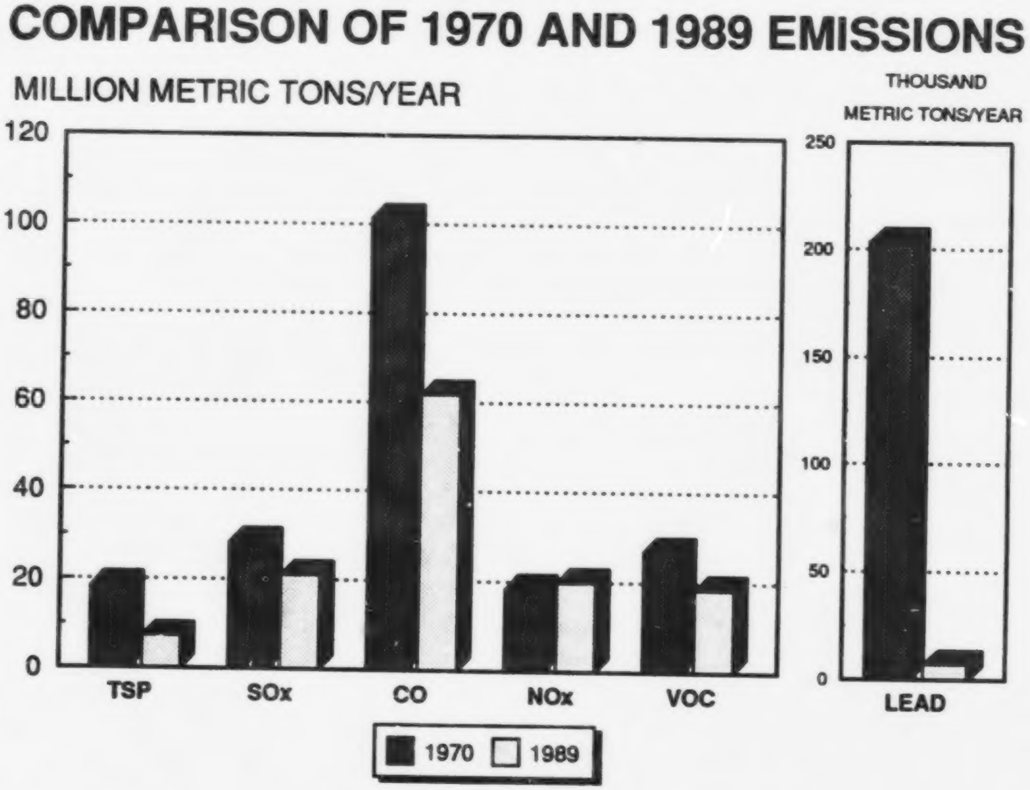


WORTH NOTING

Ambient lead (Pb) concentrations in urban areas throughout the country have shown major improvements. In 1989, unleaded gasoline sales accounted for 89 percent of the total gasoline market - up from 82 percent in 1988. The drop in Pb consumption and subsequent Pb emissions since 1980 was brought about by the increased use of unleaded gasoline in catalyst-equipped cars and the reduced Pb content in leaded gasoline. The largest single year drop in average lead concentrations, 42 percent, occurs as expected between 1985 and 1986, because of the shift of the lead content in leaded gasoline in those years.

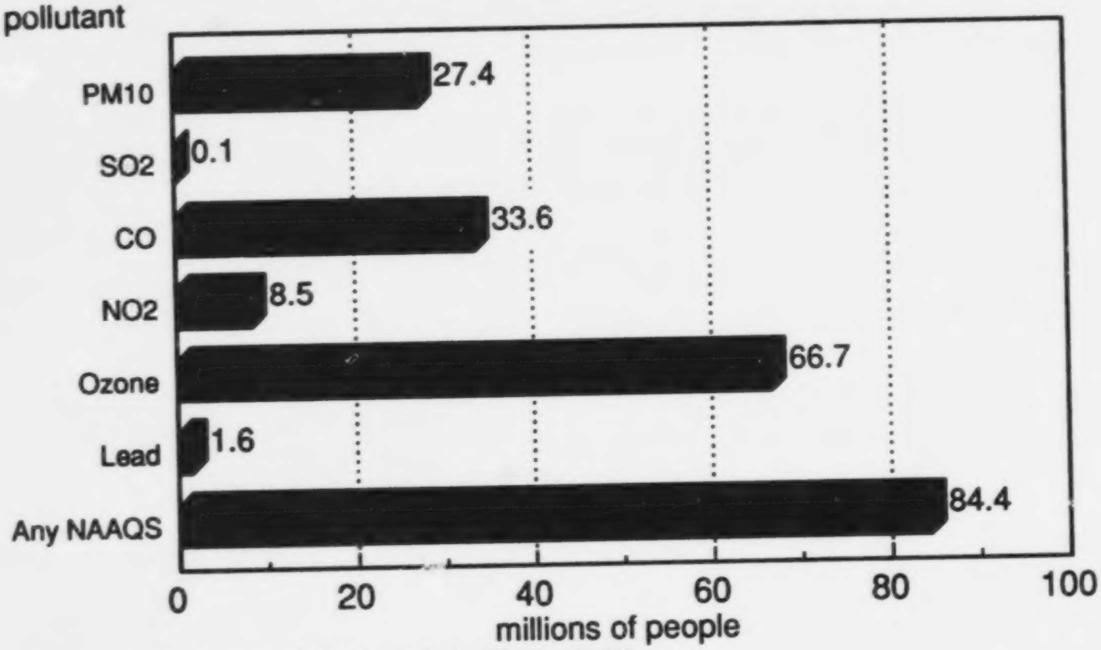
1.3 SOME PERSPECTIVE

A 10-year time period is convenient for considering ambient air pollution trends because monitoring networks underwent many changes around 1980. However, it is important not to overlook some of the earlier control efforts in the air pollution field. Emission estimates are useful in examining longer term trends. Between 1970 and 1989, lead clearly shows the most impressive decrease (-96 percent) but improvements are also seen for total suspended particulate (-61 percent), sulfur oxides (-26 percent), carbon monoxide (-40 percent), and volatile organic compounds (-31 percent). Only nitrogen oxides did not show improvement with emissions estimated to have increased 8 percent, due primarily to increased fuel combustion by stationary sources and motor vehicles. It is also important to realize that many of these reductions occurred even in the face of growth of emissions sources. More detailed information is contained in a companion report.[17]



While it is important to recognize that progress has been made, it is also important not to lose sight of the magnitude of the air pollution problem that still remains. About 84 million people in the U.S. reside in counties which did not meet at least one air quality standard during 1989. The 67 million people living in counties that exceeded the ozone standard in 1989 is 45 million fewer than in 1988. Meteorological conditions in 1988 were more conducive to ozone formation than conditions in 1989. Also, beginning in summer 1989, gasoline evaporative emissions were reduced as a result of fuel volatility regulations which lowered the Reid vapor pressure in gasoline. These statistics, and associated qualifiers and limitations, are discussed in Chapter 4.

People in counties with measured 1989 air quality above primary National Ambient Air Quality Standards



Note: Based on 1987 county population data and only 1989 air quality data.

Finally, it should be recognized that this report focuses on those pollutants that have National Ambient Air Quality Standards. With the passage of the Clean Air Act Amendments of 1990, additional control programs are being put in place to solve the remaining nonattainment problems for these pollutants.

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2. INTRODUCTION

This report focuses on 10-year (1980-89) national air quality trends for each of the major pollutants for which National Ambient Air Quality Standards (NAAQS) have been established. This Section presents many of the technical details involved in these analyses; readers familiar with previous reports may prefer initially to proceed directly to the remaining Sections. The national analyses are complemented in Section 5 with air quality trends in 14 metropolitan areas for the period 1980 through 1989. The areas examined are Atlanta, GA; Boston, MA; Chicago, IL; Dallas, TX; Denver, CO; Houston, TX; Kansas City, MO-KS; Los Angeles, CA; New York, NY; Philadelphia, PA; Pittsburgh, PA; San Francisco, CA; Seattle, WA; and Washington, DC-MD-VA.

The national air quality trends are based on the results of direct air pollution measurements at air monitoring sites located throughout the U.S. The National Air Monitoring Station (NAMS) sites were established through monitoring regulations promulgated in May 1979[1] to provide accurate and timely data to the U.S. Environmental Protection Agency (EPA) from a national air monitoring network. The NAMS are located in areas with higher pollutant concentrations and high population exposure. These stations meet uniform criteria for siting, quality assurance, equivalent analytical methodology, sampling intervals, and instrument selection to assure consistent data reporting among the States. Other sites operated by the State and local air pollution control agencies, such as the State and Local Air Monitoring Stations (SLAMS) and Special Purpose Monitors (SPM), in general, also meet the same rigid criteria, except that in addition to being located in the area of highest concentration and high population exposure, they are located in other areas as well.

Air quality status may be determined by comparing the ambient air pollution levels with the appropriate primary and secondary National Ambient Air Quality Standards (NAAQS) for each of the pollutants (Table 2-1). Primary standards protect the public health; secondary standards protect the public welfare as measured by effects of pollution on vegetation, materials, and visibility. The standards are further categorized for different averaging times. Long-term standards specify an annual or quarterly mean that may not be exceeded; short-term standards specify upper limit values for 1-, 3-, 8-, or 24-hour averages. With the exception of the pollutants ozone and PM_{10}, the short-term standards are not to be exceeded more than once per year. The ozone standard requires that the expected number of days per calendar year with daily maximum hourly concentrations exceeding 0.12 parts per million (ppm) be less than or equal to one. The 24-hour PM_{10} standard also allows one expected exceedance per year.

Trends are also presented for annual nationwide emissions. These are estimates of the amount and kinds of pollution being emitted by automobiles, factories, and other sources, based upon the best available engineering calculations for a given time period. The emission trends are taken from the EPA publication, National Air Pollutant Emission Estimates, 1940-1989[2] and the reader is referred to this publication for more detailed information. For particulates, emission estimates are presented for both total particulate emissions, without any distinction of particle sizes, as well as for PM_{10}, which refers to "inhalable" particles with aerodynamic diameter less that 10 microns. Area source fugitive dust emissions (unpaved roads, construction activities, etc.) for PM_{10} are included for the year 1985. Similarly, natural sources of PM_{10}, such as wind erosion or dust, are also shown. (Forest fires, some of which result from natural causes are included, however, for both total particulates and PM_{10}). As shown, these fugitive emissions are estimated to amount to a considerable portion of particulate emissions. For CO, VOC and NO_x, emission estimates for gasoline-and diesel-powered motor vehicles were based upon vehicle-mile tabulations and emission factors from the MOBILE 4.0 model.

Section 4 of this report, "Air Quality Levels in Metropolitan Statistical Areas" provides greatly simplified air pollution information. Air quality statistics are presented for each of the pollutants for all MSAs reporting monitoring data to EPA for 1989.

TABLE 2-1. National Ambient Air Quality Standards (NAAQS) in Effect in 1989.

POLLUTANT	PRIMARY (HEALTH RELATED)		SECONDARY (WELFARE RELATED)	
	Averaging Time	Standard Level Concentration[a]	Averaging Time	Standard Level Concentration
PM$_{10}$	Annual Arithmetic Mean[b]	50 $\mu g/m^3$	Same as Primary	
	24-hour[b]	150 $\mu g/m^3$	Same as Primary	
SO$_2$	Annual Arithmetic Mean	(0.03 ppm) 80 $\mu g/m^3$	3-hour[c]	1300 $\mu g/m^3$ (0.50 ppm)
	24-hour[c]	(0.14 ppm) 365 $\mu g/m^3$		
CO	8-hour[c]	9 ppm (10 mg/m^3)	No Secondary Standard	
	1-hour[c]	35 ppm (40 mg/m^3)	No Secondary Standard	
NO$_2$	Annual Arithmetic Mean	0.053 ppm (100 $\mu g/m^3$)	Same as Primary	
O$_3$	Maximum Daily 1-hour Average[d]	0.12 ppm (235 $\mu g/m^3$)	Same as Primary	
Pb	Maximum Quarterly Average	1.5 $\mu g/m^3$	Same as Primary	

[a] Parenthetical value is an approximately equivalent concentration.

[b] TSP was the indicator pollutant for the original particulate matter (PM) standards. This standard has been replaced with the new PM$_{10}$ standard and it is no longer in effect. New PM standards were promulgated in 1987, using PM$_{10}$ (particles less than 10u in diameter) as the new indicator pollutant. The annual standard is attained when the expected annual arithmetic mean concentration is less than or equal to 50 $\mu g/m^3$; the 24-hour standard is attained when the expected number of days per calendar year above 150 $\mu g/m^3$ is equal to or less than 1; as determined in accordance with Appendix K of the PM NAAQS.

[c] Not to be exceeded more than once per year.

[d] The standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm is equal to or less than 1, as determined in accordance with Appendix H of the Ozone NAAQS.

2.1 DATA BASE

The ambient air quality data used in this report were obtained from EPA's Aerometric Information and Retrieval System (AIRS). Air quality data are submitted to AIRS by both State and local governments, as well as federal agencies. At the present time, there are about 500 million air pollution measurements on AIRS, the vast majority of which represent the more heavily populated urban areas of the nation.

In order for a monitoring site to have been included in the national 10-year trend analysis, the site had to contain complete data for at least 8 of the 10 years 1980 to 1989. For the regional comparisons, the site had to report data in each of the last three years to be included in the analysis. Table 2-2 displays the number of sites meeting the completeness criteria for both data bases. For PM_{10}, whose monitoring network has just been initiated over the last few years, analyses are based on 357 sites with data in 1988 and 1989. Data for each year had to satisfy annual data completeness criteria appropriate to pollutant and measurement methodology. The air quality data are divided into two major groupings -- 24-hour measurements and continuous 1-hour measurements. The 24-hour measurements are obtained from monitoring instruments that produce one measurement per 24-hour period and are typically operated on a systematic sampling schedule of once every 6 days, or 61 samples per year. Such instruments are used to measure TSP, PM_{10}, SO_2, NO_2 and Pb. For PM_{10}, more frequent sampling of every other day or everyday is now also common. Data collected only as 24-hour measurements were not used in the SO_2 and NO_2 trends analyses because these methods have essentially been phased out of the monitoring network. Total suspended particulate and PM_{10} data were judged adequate for trends if there were at least 48 samples for the year. Both 24-hour and composite data were used in the Pb trends analyses. The 24-hour Pb data had to have at least six samples per quarter in at least 3 of the 4 calendar quarters. Monthly composite Pb data were used if at least two monthly samples were available for at least 3 of the 4 calendar quarters.

The 1-hour data are obtained from monitoring instruments that operate continuously, producing a measurement every hour for a possible total of 8760 hourly measurements in a year. For continuous hourly data, a valid annual mean for SO_2 and NO_2 trends requires at least 4380 hourly observations. This same annual data completeness, of at least 4380 hourly values, was required for the CO standard related statistics - the second maximum nonoverlapping 8-hour average and the estimated number of exceedances of the 8-hour average CO standard. A slightly different criterion was used for the SO_2 standard related daily statistics - the second daily maximum 24-hour average and the estimated number of daily exceedances of the SO_2 standard. Instead of requiring 4380 or more hourly values, 183 or more daily values were required. A valid day is defined as one consisting of at least 18 hourly observations. This produces a slightly different data base of sites used in the national analysis for the daily SO_2 statistics.

Finally, because of the seasonal nature of ozone, both the second daily maximum 1-hour value and the estimated number of exceedances of the O_3 NAAQS were calculated for the ozone season, which typically varies by State.[3] For example, in California, the ozone season is defined as 12 months, January through December, while in New Jersey it is defined as 7 months, April through October. In order for a site to be included, at least 50 percent of its daily data had to be available for the ozone season.

The use of a moving 10-year window for trends yields a data base that is more consistent with the current monitoring network and reflects the period following promulgation of uniform monitoring requirements. In addition, this procedure increased the total number of trend sites by 3 percent for the 10-year period relative to the data bases used in the last annual report.[4] However, the reader should note that the size of the TSP monitoring network has been declining, especially since promulgation of the PM_{10} standard.

TABLE 2-2. Number of Air Quality Trend Sites, 1980-89 and 1987-89.

POLLUTANT	NUMBER OF SITES 1980-89	 1987-89
Total Suspended Particulate (TSP)*	1648	1014
Sulfur Dioxide (SO_2)	409	513
Carbon Monoxide (CO)	280	355
Nitrogen Dioxide (NO_2)	178	200
Ozone (O_3)	431	581
Lead (Pb)	189	245
TOTAL	3105	2908

* Changes in PM_{10} air quality are based on 357 sites with data in 1988 and 1989.

2.2 TREND STATISTICS

The air quality analyses presented in this report comply with the recommendations of the Intra-Agency Task Force on Air Quality Indicators.[5] The air quality statistics used in these pollutant-specific trend analyses relate to the appropriate NAAQSs. Two types of standard-related statistics are used - peak statistics (the second maximum 24-hour SO_2 average, the second maximum nonoverlapping 8-hour CO average, and the second daily maximum 1-hour O_3 average) and long-term averages (the annual geometric mean for TSP, the annual arithmetic means for PM_{10}, SO_2 and NO_2, and the quarterly arithmetic mean for Pb). In the case of the peak statistics, the second maximum value is used, because this is the value which traditionally has been used to determine whether or not a site has or has not met an air quality standard in a particular year. For PM_{10}, with its variable sampling frequency, the 90th percentile of 24-hour concentrations is used to examine changes in peak values. A composite average of each of these statistics is used in the graphical presentations which follow. All sites were weighted equally in calculating the composite average trend statistic. Missing annual summary statistics for the second through ninth years for a site are estimated by linear interpolation from the surrounding years. Missing end points are replaced with the nearest valid year of data. This procedure results in a statistically balanced data set to which simple statistical procedures can be applied. The procedure is also conservative, because end-point rates of change are dampened by the interpolated estimates.

This report presents statistical confidence intervals to facilitate a better understanding of measured changes in air quality. Confidence intervals are placed around composite averages, which are based on sites that satisfy annual data completeness requirements. The confidence intervals can be used to make comparisons between years; if the confidence intervals for any 2 years do not overlap, then the composite averages of the 2 years are significantly different (Figure 2-1).

Ninety-five percent confidence intervals for composite averages of annual means (arithmetic and geometric) and second maxima were calculated from a two-way analysis of variance followed by an application of the Tukey Studentized Range.[6] The confidence intervals for composite averages of estimated exceedances were calculated by fitting Poisson distributions[7] to the exceedances each year and then applying the Bonferroni multiple comparisons procedure.[8] The utilization of these procedures is explained in publications by Pollack, Hunt and Curran[9] and Pollack and Hunt.[10]

Boxplots[11] are used to present air quality trends because they have the advantage of displaying, simultaneously, several features of the data. Figure 2-2 illustrates the use of this technique in presenting the 5th, 10th, 25th, 50th (median), 75th, 90th and 95th percentiles of the data, as well as the composite average. The 5th, 10th and 25th percentiles depict the "cleaner" sites. The 75th, 90th and 95th depict the "higher" sites, and the median and average describe the "typical" sites. For example, 90 percent of the sites would have concentrations equal to or lower than the 90th percentile. Although the average and median both characterize typical behavior, the median has the

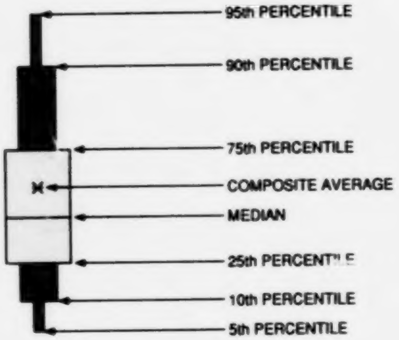

Figure 2-2. Illustration of plotting convention of boxplots.

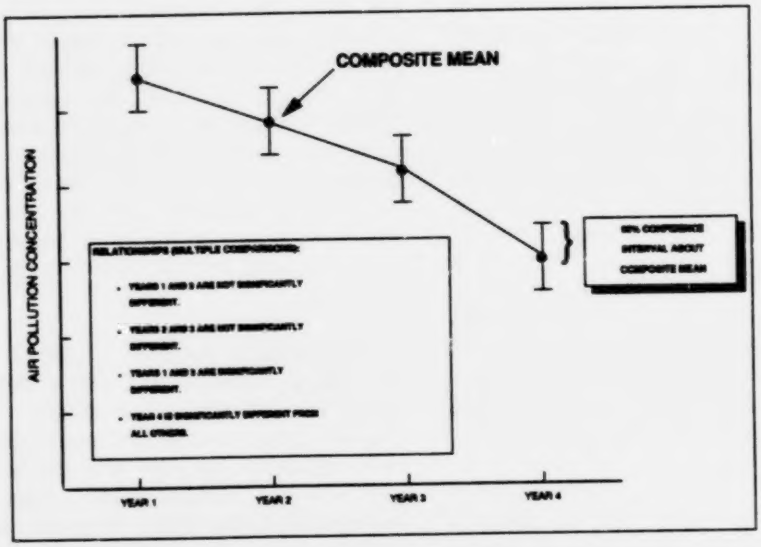

Figure 2-1. Sample illustration of use of confidence intervals to determine statistically significant change.

advantage of not being affected by a few extremely high observations. The use of the boxplots allows us simultaneously to compare trends in the "cleaner", "typical" and "higher" sites.

Bar graphs are introduced for the Regional comparisons with the 3-year trend data base. These comparisons are based on the ten EPA Regions (Figure 2-3). The composite averages of the appropriate air quality statistic of the years 1987, 1988 and 1989 are presented. The approach is simple, and it allows the reader at a glance to compare the short-term changes in all ten EPA Regions.

In addition to concentration related statistics, other statistics are used, when appropriate, to clarify further the observed air quality trends. Particular attention is given to the estimated number of exceedances of the short-term NAAQSs. The estimated number of exceedances is the measured number of exceedances adjusted to account for incomplete sampling. Trends in exceedances tend to be more variable than in the other concentration related statistics, particularly on a percentage basis. For example, a site may show a 50 percent decrease in annual exceedances, from 2 to 1 per year, and yet record less than a 5 percent decrease in average concentration levels. The change in concentration levels is likely to be more indicative of changes in emission levels.

Trends are also presented for annual nationwide emissions. These emissions data are estimated using the best available engineering calculations. The emissions data are reported as teragrams (one million metric tons) emitted to the atmosphere per year, with the exception of lead emissions, which are reported as gigagrams (one thousand metric tons).[2] These are estimates of the amount and kinds of pollution being generated by automobiles, factories and other sources. Estimates for earlier years are recomputed using current methodology so that these estimates are comparable over time.

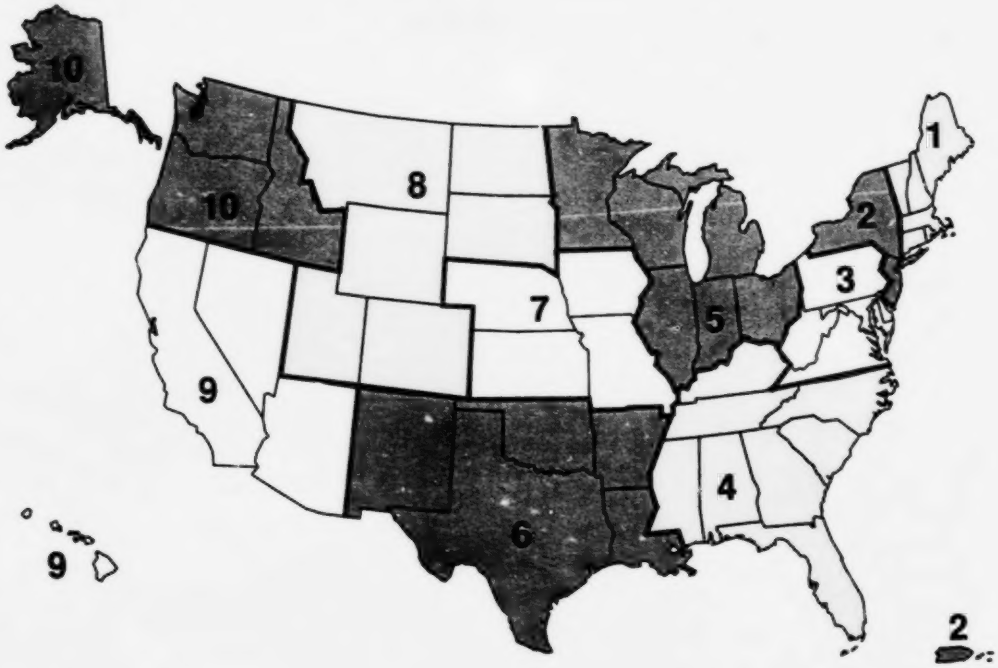

Figure 2-3. Ten Regions of the U.S. Environmental Protection Agency.

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3. NATIONAL AND REGIONAL TRENDS IN NAAQS POLLUTANTS

EPA has set National Ambient Air Quality Standards (NAAQS) for six pollutants considered harmful to public health: particulate matter [formerly as total suspended particulates (TSP), now as particulates less than 10 microns in diameter (PM_{10})], sulfur dioxide (SO_2), carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3) and lead (Pb). This chapter focuses on both 10-year (1980-89) trends and recent changes in air quality and emissions for these six pollutants. Changes since 1987, and comparisons between all the trend sites and the subset of National Air Monitoring Stations (NAMS) are highlighted. Trends are examined for both the nation and the ten EPA Regions.

As in previous reports, the air quality trends are presented using trend lines, confidence intervals, boxplots and bar graphs. The reader is referred to Section 2.2 for a detailed description of the confidence interval and boxplot procedures. The plotting conventions for the confidence intervals and boxplots are shown in Figures 2-1 and 2-2 respectively. Boxplots of all trend sites are presented for each year in the 10-year trend. Recent changes are presented using the 3-year data base, 1987 through 1989, and using a 1988-89 data base for PM_{10}. The recent 3-year period is presented to take advantage of the larger number of sites for all but particulates, and of sites that have operated continuously during the last three years.

Trends are also presented for annual nationwide emissions of particulate matter, sulfur oxides (SOx), carbon monoxide (CO), nitrogen oxides (NOx), volatile organic compounds (VOC) and lead (Pb). These emissions data are estimated using best available engineering calculations. The reader is referred to a companion report for a detailed description of emission trends, source categories and estimation procedures.[1] For particulates, emission estimates are presented both in terms of total particulate matter, which includes all particles regardless of size, and for PM_{10}. This report introduces short-term particulate matter trends relating to PM_{10} air quality and emissions data.

While the ambient data trends and the emission trends can be viewed as independent assessments that lend added credence to the results, the emission estimates can be used to provide information on trends over longer time periods. Because of changes that have occurred in ambient monitoring measurement methodology and the change over time in the geographical distribution of monitors, it is difficult to provide ambient trends going back to 1970, other than for TSP, and yet it is important not to lose sight of some of the earlier progress that was made in air pollution control. Emission estimates can provide some insight in this area. Figure 3-1 depicts long-term change in emission estimates. Lead clearly shows the most impressive decrease of 96 percent but improvements are also seen for TSP (-61 percent), SOx (-26 percent), CO (-40 percent), and VOC (-31 percent). Only NOx has not shown improvement with emissions estimated to have increased 8 percent, due primarily to increased fuel combustion by stationary sources. Because all areas except Los Angeles, CA meet the current NAAQS for NO_2, it is probably not surprising that the other pollutants are where the emission reductions have occurred.

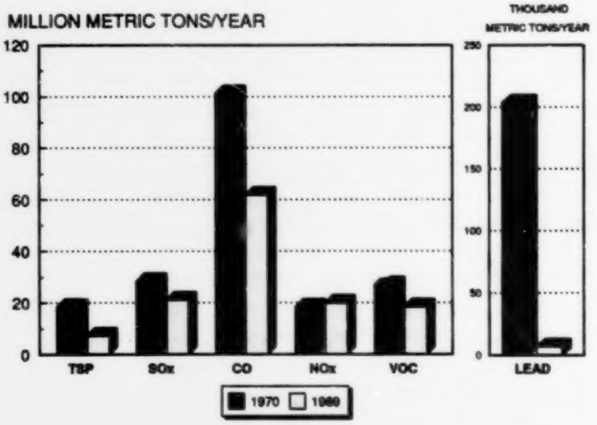


Figure 3-1. Comparison of 1970 and 1989 emissions.

3.1 TRENDS IN PARTICULATE MATTER

Air pollutants called particulate matter include dust, dirt, soot, smoke and liquid droplets directly emitted into the air by sources such as factories, power plants, cars, construction activity, fires and natural windblown dust as well as particles formed in the atmosphere by condensation or transformation of emitted gases such as sulfur dioxide and volatile organic compounds.

Annual and 24-hour National Ambient Air Quality Standards (NAAQS) for particulate matter were first set in 1971. Total suspended particulate (TSP) was the indicator used to represent suspended particles in the ambient air. TSP is measured using a high volume sampler (Hi-Vol) which collects suspended particles ranging up to approximately 45 micrometers in diameter.

On July 1, 1987 EPA promulgated new annual and 24-hour standards for particulate matter, using a new indicator, PM_{10}, that includes only those particles with aerodynamic diameter smaller than 10 micrometers. These smaller particles are likely responsible for most adverse health effects of particulate because of their ability to reach the thoracic or lower regions of the respiratory tract. The original (TSP) standards were an annual geometric mean of 75 $\mu g/m^3$, not to be exceeded, and a 24-hour concentration of 260 $\mu g/m^3$, not to be exceeded more than once per year. The new (PM_{10}) standards specify an expected annual arithmetic mean not to exceed 50 $\mu g/m^3$ and an expected number of 24-hour concentrations greater than 150 $\mu g/m^3$ per year not to exceed one.

Now that the standards have been revised, PM_{10} monitoring networks are being deployed nationally. There are basically two types of reference instruments currently used to sample PM_{10}. The first is essentially a Hi-Vol, like the one used for TSP, but with a different size selective inlet (SSI). This sampler uses an inert quartz filter. The other type of instrument is a "dichotomous" sampler. It uses a different PM_{10} inlet, operates at a slower flow rate, and produces two separate samples: 2.5 to 10 microns and less than 2.5 microns, each collected on a teflon filter.

With the new PM_{10} standards, more emphasis is being placed on detection of peak 24-hour concentrations. Unlike monitoring regulations for TSP which only required once in 6 day sampling, new specifications for PM_{10} now dictate more frequent sampling. Approximately 15 percent of all PM_{10} sampling sites operate either every other day or everyday. In contrast, only 5 percent of TSP Hi-Vols operate more frequently than once in 6 days.

Although some monitoring for PM_{10} was initiated prior to promulgation of the new standards, most networks did not produce data with approved reference samplers until mid-1987 or 1988. Thus, only a limited data base is currently available to examine trends in PM_{10} air quality. Accordingly, longer-term trends in particulate matter are based primarily on TSP. Both 10-year trends and recent 3-year changes in TSP are presented in terms of average air quality (annual geometric mean). In addition, available information on PM_{10} air quality will be used to report the 1988-1989 change in PM_{10} concentration levels. Two PM_{10} statistics are presented. The annual arithmetic mean concentration is used to reflect average air quality, and the 90th percentile of 24-hour concentrations is used to represent the behavior of peak concentrations. Because PM_{10} sampling frequency varies among sites and may have changed during the 2-year period, the 90th percentile is used. This statistic is less sensitive to changes in sampling frequency than the peak values. Finally, cross sectional PM_{10} data are included for the more comprehensive data available for calendar year 1989.

3.1.1 Long-term TSP Trends: 1980-89

The 10-year trend in average TSP levels, 1980 through 1989, is shown in Figure 3-2 for 1648 sites geographically distributed throughout the Nation. Trends are also shown for the subset of 219 National Air Monitoring Stations (NAMS) which are located in areas of greater than 50,000 in population. The TSP levels are expressed in terms of the composite average annual geometric mean.

The curves in Figure 3-2 show very similar trends for both the NAMS and the larger group of sites, although composite particulate concentrations are higher for the NAMS. For both curves, measured TSP concentrations appear to have declined during the first 2 years of the 10-year period and are relatively stable in the later years. However, the data collected during 1979 to 1981 may have been affected by the type of filters used to collect the TSP.[2-5] For this reason, the portion of Figure 3-2 corresponding to the years 1980-1981 are shaded, to indicate the uncertainty in the TSP measurements collected during this period. Nevertheless, a 20 percent decrease between 1978 and 1982 has been well documented. Since the exact year-to-year changes during the 1980 to 1982 period are uncertain, the longer-term change in total particulate concentrations is described in terms of the 8-year period 1982-1989.

Figure 3-2 also includes 95 percent confidence intervals developed for the composite annual estimates. It can be seen that the estimates for 1982 - 1989 are relatively stable and are all significantly lower than those of 1980 - 1981. Nationally, the composite average TSP levels declined 1 percent from 1982 to 1989. Upon close inspection, some slight changes since 1982 are evident. First, the minimum composite TSP levels occurred during the years 1985 and 1986. Second, statistically significant changes were detected during the last 4 years, with the 1989 concentration levels returning to the lower concentrations observed in the mid-1980's. No statistically significant differences are noted for the smaller group of TSP NAMS trend sites. These recent changes in total suspended particulate matter will be discussed in more detail in Section 3.1.3.

The long-term trends in TSP are also illustrated in Figure 3-3. Using the same national data base of 1648 TSP sites, Figure 3-3 shows the yearly change in the entire national concentration distribution using boxplot displays. The large difference between 1980-1981 and the subsequent years is evident for the entire concentration distribution. During

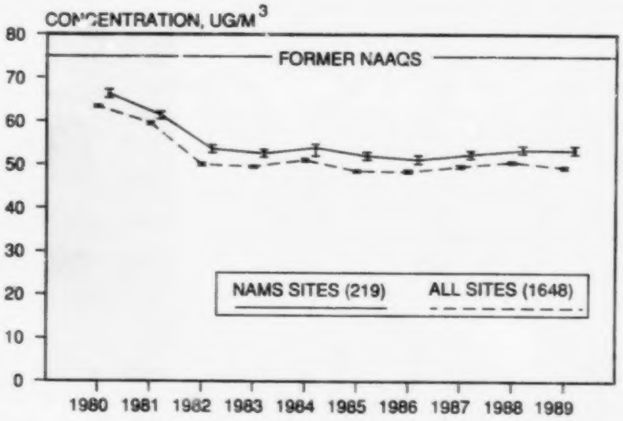


Figure 3-2. National trend in the composite average of the geometric mean total suspended particulate at both NAMS and all sites with 95 percent confidence intervals, 1980-1989.

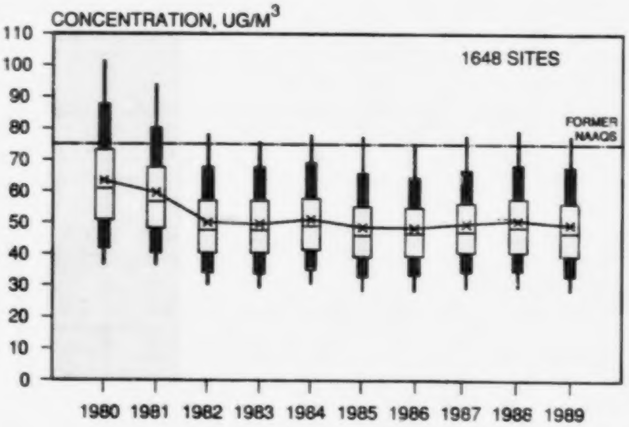


Figure 3-3. Boxplot comparisons of trends in annual geometric mean total suspended particulate concentrations at 1648 sites, 1980-1989.

the last 8 years, the national TSP distribution shows little change, although more improvement is apparent among the cleanest 10 percent of the sites.

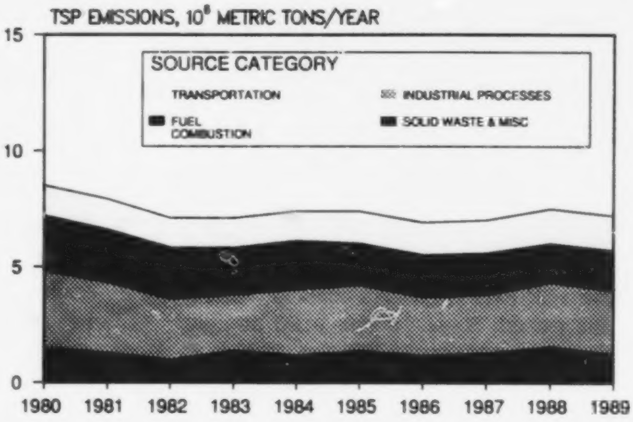


Figure 3-4. National trend in particulate emissions, 1980-1989.

3.1.2 TSP Emission Trends

Nationwide TSP emission trends show an overall decrease of 15 percent from 1980 to 1989. Over the 8 years, 1982-1989, these total particulate emissions remained relatively constant. (See Table 3-1 and Figure 3-4). The trend in PM emissions is normally not expected to agree precisely with the trend in ambient TSP levels, however, due to unaccounted for natural PM background and uninventoried emission sources such as unpaved roads and construction activity. Such fugitive emissions are not considered in estimates of the annual nationwide total and could be significant in populated areas. Information on these sources is presented in terms of the PM_{10} portion of particulate matter in Section 3.1.5. The 10-year reductions in inventoried particulate emissions occurred primarily in the fuel combustion and industrial processes categories. This is attributed to installation of control equipment by electric utilities, despite an increase in fuel comsumed and also to reduced activity in some industries, such as iron and steel.[1] A large increase in the miscellaneous category for 1988 is attributed to the forest fires which occurred that year. Total particulate emissions are estimated to have decreased 4 percent from 1988 to 1989.

TABLE 3-1. NATIONAL TOTAL SUSPENDED PARTICULATE EMISSION ESTIMATES, 1980-1989

(million metric tons/year)										
SOURCE CATEGORY	**1980**	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**
Transportation	1.3	1.3	1.3	1.3	1.3	1.4	1.4	1.4	1.5	1.5
Fuel Combustion	2.4	2.3	2.2	2.0	2.1	1.8	1.8	1.8	1.7	1.8
Industrial Processes	3.3	3.0	2.6	2.4	2.8	2.8	2.5	2.5	2.7	2.7
Solid Waste	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Miscellaneous	1.1	0.9	0.7	1.1	0.9	1.1	0.9	1.0	1.3	1.0
TOTAL	8.5	8.0	7.1	7.1	7.4	7.3	6.8	7.0	7.5	7.2

NOTE: The sums of sub-categories may not equal total due to rounding.

3.1.3 Recent TSP Trends: 1987-89

The TSP trends for the 3-year period 1987-1989 are presented in terms of 1014 sites which produced data in each of the last 3 years. The group of sites qualifying for this analysis is smaller than the group used to analyze long-term trends, reflecting the revisions to TSP SLAMS networks and the shift of particulate monitoring to PM_{10}. Nationally, little change occurred between 1987 and 1989, although 1988 produced statistically higher concentrations. On the basis of the 1014 sites with data in 1987, 1988 and 1989, average TSP concentrations were highest in 1988 and were lowest in 1989. Nationally, average concentrations decreased 5 percent between these 2 years. This 3-year pattern was not consistent, however, among geographic Regions of the country.

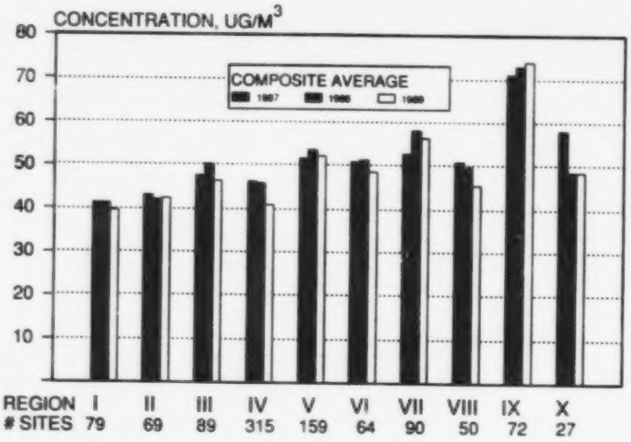


Figure 3-5. Regional comparisons of the 1987, 1988 and 1989 composite averages of the geometric mean total suspended particulate concentrations.

Figure 3-5 focuses on the last 3 years with a bar chart of Regional average TSP. Overall there were relatively small changes in most Regions. The most notable difference occurred in the western most Regions. For Region IX (AZ, CA, HI, NV), total particulate concentrations showed a slight but steady increase. This is attributed to the extended drought in this Region. In Region X (AK, ID, OR, WA), total particulate levels sharply declined, and then showed no change between the last 2 years. This change is due to abnormally high 1987 particulate levels associated with an unusual number of wildfires in the Pacific Northwest.[6]

The observed year-to-year variations in particulate levels may in part be attributable to meteorology. Among all meteorological parameters, precipitation has been shown to have had the greatest influence on particulate air quality. Rainfall has the effect of reducing reentrainment of particles and of washing particles out of the air. Generally drier conditions are also associated with an increase in forest fires.

During 1988, most of the nation experienced an extreme drought. Nationally, this year was the driest since 1956 and the second driest in the last 50 years. Most of the Nation returned to more normal annual rainfall in 1989. The drought worsened, however, in EPA Region IX where annual rainfall declined 18 percent.[7]

3.1.4 Recent PM_{10} Air Quality

The 1988-1989 change in the PM_{10} portion of total particulate concentrations is examined at 357 monitoring locations which produced data in both years. A more comprehensive national sample of 763 sites is also presented to provide a more representative indication of PM_{10} air quality produced by reference PM_{10} samplers.

The sample of 357 "trend" sites reveals a small but statistically significant 3 percent decrease in average PM_{10} concentrations. This is consistent with the 5 percent decrease in total particulates described earlier. Peak 24-hour PM_{10} concentrations decreased 3 percent. This was examined in terms of the average of the 90th percentiles of 24-hour concentrations among sampling locations.

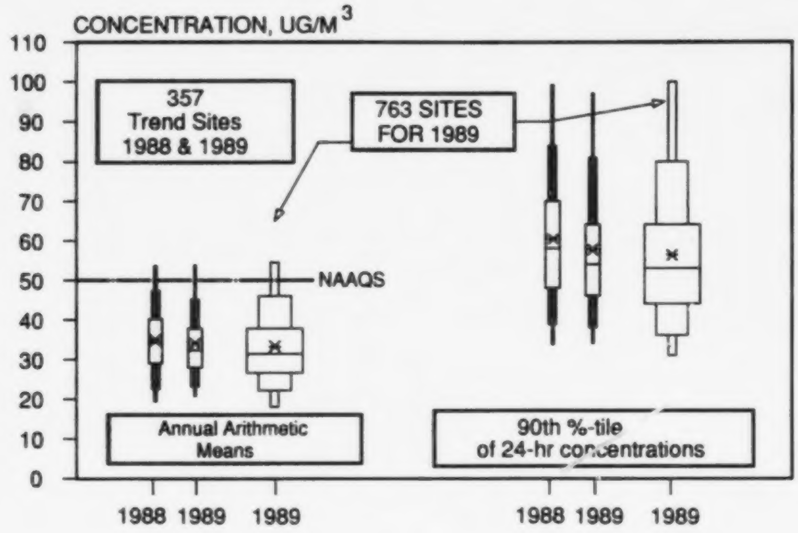


Figure 3-6. Boxplot comparisons of the 2-year change in PM_{10} concentrations (1988-1989) at 357 sites with 1989 PM_{10} air quality at 763 sites.

Figure 3-6 displays boxplots of the concentration distribution for the two PM_{10} trend statistics - annual arithmetic mean and 90th percentile of 24-hour concentrations. The 1988 and 1989 national distributions are very similar for both annual average and 90th percentile of 24-hour PM_{10} concentrations. Figure 3-6 also displays the concentration distributions for the larger sample of 763 sites. While the larger group of sites is 2 percent lower in the composite average annual arithmetic mean, it also has a slightly higher percentage of high concentrations sites.

The more representative 1989 concentration distribution of annual arithmetic means also provides a basis for direct comparison to the annual standard of 50 $\mu g/m^3$. Approximately 7 percent of monitoring stations reported averages above the annual standard.

Although the 90th percentile is a reasonable peak concentration indicator for temporal comparisons, it does not directly relate to the 150 $\mu g/m^3$ level of the 24-hour PM_{10} standard. Since this standard permits one expected exceedance per

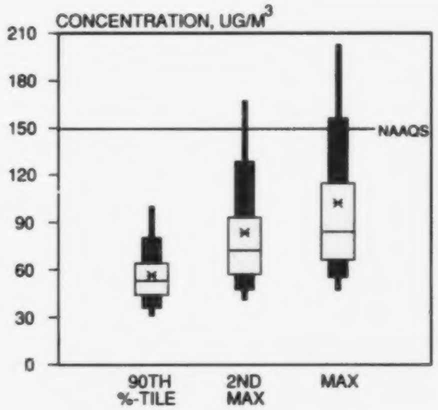


Figure 3-7. Boxplot comparisons of 24-hour PM_{10} peak value statistics for 1989 at 763 sites.

year, the maximum and second maximum 24-hour concentrations provide a more direct indication of attainment status. A comparison of the 90th percentile of 24-hour concentrations to these other indicators of peak concentrations is presented in Figure 3-7 using boxplots of the 1989 national concentration distribution. Although the 90th percentile concentrations are well below 150 μg/m³, maximum concentrations exceed the standard at 11 percent of the reporting locations while the second maximum concentrations exceed at 7 percent.

Figure 3-8 presents the Regional distribution of PM_{10} concentrations for both average and 90th percentile concentrations among the 763 stations producing reference measurements in 1989. The highest average and peak 24-hour concentrations are seen in Regions IX and X.

The 90th percentile of 24-hour concentrations has been used as the indicator of peak concentrations because of differences in sampling frequency among PM_{10} sampling locations. Note that average sampling frequency varies among Regions, with samplers in Regions VIII and X operating at more than twice the frequency of samples in Region II and Region IX. The monitoring regulations permit such differences in sampling frequency. The regulations specify that only areas that are close to the 24-hour standard must sample more frequently.

Figure 3-9 presents the 2-year change in annual average and 90th percentile PM_{10} concentrations by EPA Region. The slight national decrease is evident in most Regions. The PM_{10} increase seen in Region IX is consistent with the change in total particulates reported earlier, but is not statistically significant. Due to the drought in the Southwestern United States, particulate levels may be higher than normal. Region IX's 1989 rainfall was 31 percent below normal.

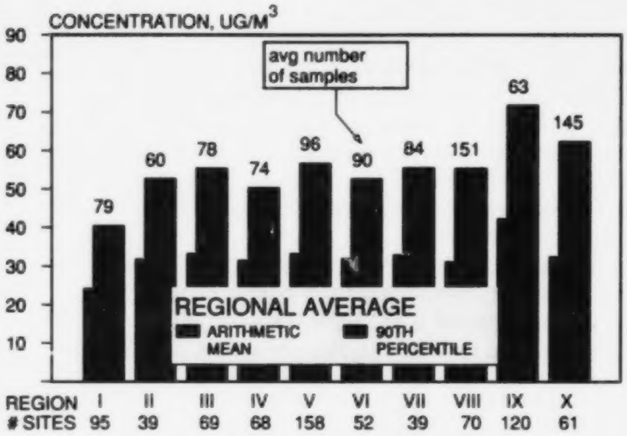


Figure 3-8. Regional comparisons of annual mean and 90th percentile of 24-hour PM_{10} concentrations for 1989.

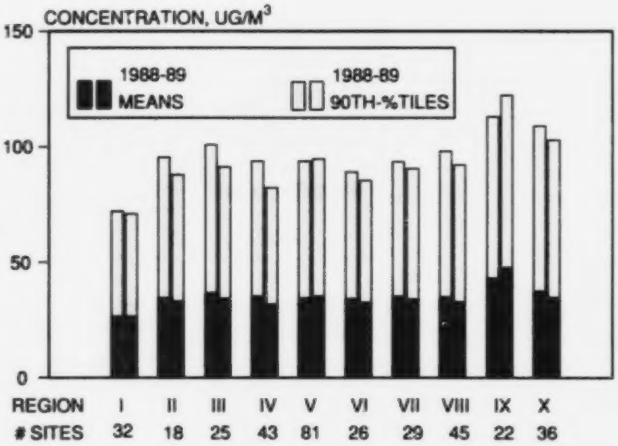


Figure 3-9. Regional changes in annual average and 90th percentile of 24-hour PM_{10} concentrations, 1988-1989.

3.1.5 PM$_{10}$ Emission Trends

Trends in the PM$_{10}$ portion of particulate matter emissions are presented for the five-year period, 1985-1989 in Table 3-2. These estimates indicate that virtually no change had occurred in the "traditional" source categories during this five year period. Furthermore, PM$_{10}$ appears to represent essentially all of the particulate emissions from transportation sources and most of the emissions in the other traditional source categories. As was the case for TSP, higher emissions occurred in 1988 due to forest fires. National estimates are also provided for PM$_{10}$ fugitive emissions for the single year, 1985, in Table 3-3. The 1985 data was selected because it represents the best available inventory of fugitive emissions. In total, these fugitive emissions are 8 times more than the traditional particulate matter sources categories. Regional breakdowns reveal that particulates attributed to wind erosion are highest in the Southwest (Region VI) and the Rocky Mountain States (Region VIII), while emissions from unpaved roads are high in all Regions covering large geographic areas.[1]

TABLE 3-2. NATIONAL PM$_{10}$ EMISSION ESTIMATES, 1985-1989

	(million metric tons/year)				
SOURCE CATEGORY	**1985**	**1986**	**1987**	**1988**	**1989**
Transportation	1.3	1.3	1.3	1.4	1.5
Fuel Combustion	1.2	1.2	1.2	1.2	1.3
Industrial Processes	2.4	2.1	2.1	2.3	2.3
Solid Waste	0.2	0.2	0.2	0.2	0.2
Miscellaneous	0.8	0.6	0.7	1.0	0.7
TOTAL	5.9	5.5	5.6	6.1	5.9

NOTE: The sums of sub-categories may not equal total due to rounding.

TABLE 3-3. 1985 FUGITIVE EMISSIONS FOR PM_{10}

SOURCE CATEGORY	MILLION METRIC TONS/YR
Agricultural Tilling	7.4
Burning	0.7
Construction	12.2
Mining and Quarrying	0.4
Paved Roads	5.9
Unpaved Roads	17.3
Wind Erosion	3.8
TOTAL	47.7

3.2 TRENDS IN SULFUR DIOXIDE

Ambient sulfur dioxide (SO_2) results largely from stationary source coal and oil combustion, refineries, pulp and paper mills and from nonferrous smelters. There are three NAAQS for SO_2: an annual arithmetic mean of 0.03 ppm (80 $\mu g/m^3$), a 24-hour level of 0.14 ppm (365 $\mu g/m^3$) and a 3-hour level of 0.50 ppm (1300 $\mu g/m^3$). The first two standards are primary (health-related) standards, while the 3-hour NAAQS is a secondary (welfare-related) standard. The annual mean standard is not to be exceeded, while the short-term standards are not to be exceeded more than once per year. The trend analyses which follow are for the primary standards. It should be noted that EPA is currently evaluating the need for a new shorter-term 1-hour standard.[8]

Although this report does not directly address trends in acid deposition, of which SO_2 is a major contributor, it does include information on total nationwide emissions which is a measure relating to total atmospheric loadings.

The trends in ambient concentrations are derived from continuous monitoring instruments which can measure as many as 8760 hourly values per year. The SO_2 measurements reported in this section are summarized into a variety of summary statistics which relate to the SO_2 NAAQS. The statistics on which ambient trends will be reported are the annual arithmetic mean concentration, the second highest annual 24-hour average (summarized midnight to midnight), and the expected annual number of 24-hour exceedances of the 24-hour standard of 0.14 ppm.

3.2.1 Long-term SO_2 Trends: 1980-89

The long-term trend in ambient SO_2, 1980 through 1989, is graphically presented in Figures 3-10 through 3-12. In each figure, the trend at the NAMS is contrasted with the trend at all sites. For each of the statistics presented, a 10-year downward trend is evident, although the rate of decline has slowed over the last 3 years. Nationally, the annual mean SO_2, examined at 409 sites, decreased at a median rate of approximately 3 percent per year; this resulted in an overall change of about 24 percent (Figure 3-10). The subset of 133 NAMS recorded higher average

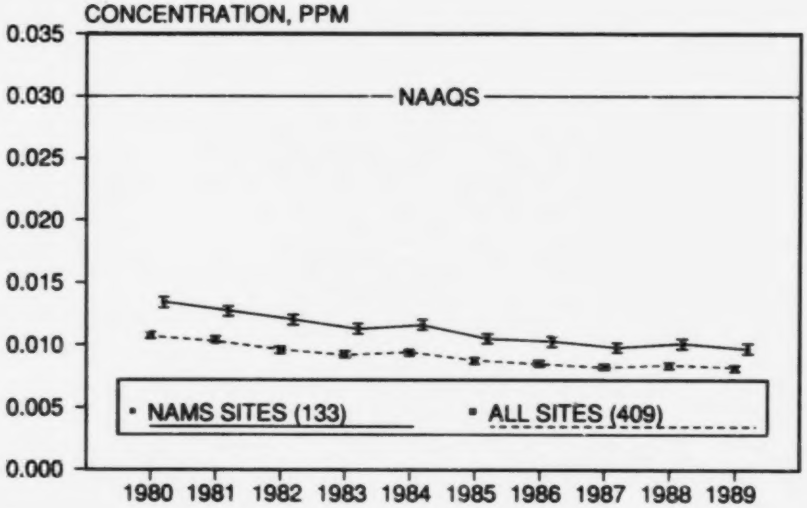


Figure 3-10. National trend in annual average sulfur dioxide concentration at both NAMS and all sites with 95 percent confidence intervals, 1980-1989.

concentrations and also declined at the same median rate, with a net change of 28 percent for the 10-year period.

The annual second highest 24-hour values displayed a similar improvement between 1980 and 1989. Nationally, among 405 stations with adequate trend data, the median rate of change was 3 percent per year, with an overall decline of 26 percent (Figure 3-11). The 135 NAMS exhibited an overall decrease of 30 percent. The estimated number of exceedances also showed declines for the NAMS as well as for the composite of all sites (Figure 3-12). The national composite estimated number of exceedances decreased 95 percent from 1980 to 1989. However, the vast majority of SO_2 sites do not show any exceedances of the 24-hour NAAQS. Most of the exceedances, as well as the bulk of the improvements, occurred at source-oriented sites.

The statistical significance of these long-term trends is graphically illustrated in Figures 3-10 to 3-12 with the 95 percent confidence intervals. These figures show that the SO_2 levels are statistically indistinguishable among the last 3 years. For both annual averages and peak 24-hour values, the 1989 composite average is significantly lower than levels recorded before 1986. For expected exceedances of the 24-hour standard, which experienced a more rapid decline, the 1989 values are only statistically different than the levels for 1984 and 1980 to 1982.

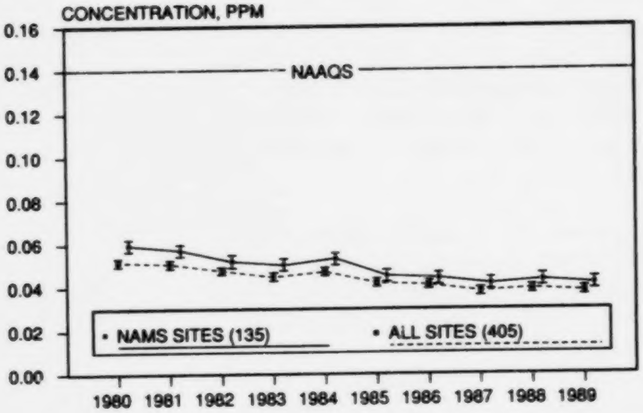


Figure 3-11. National trend in the second-highest 24-hour sulfur dioxide concentration at both NAMS and all sites with 95 percent confidence intervals, 1980-1989.

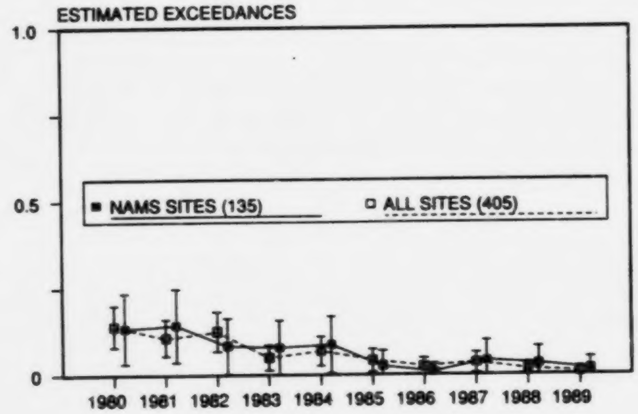


Figure 3-12. National trend in the estimated number of exceedances of the 24-hour sulfur dioxide NAAQS at both NAMS and all sites with 95 percent confidence intervals, 1980-1989.

The inter-site variability for annual mean and annual second highest 24-hour SO_2 concentrations is graphically displayed in Figures 3-13 and 3-14. These figures show that higher concentrations decreased more rapidly and that the concentration range among sites has also diminished during the 1980's.

Nationally, sulfur oxides (SOx) emissions decreased 10 percent from 1980 to 1989 (Figure 3-15 and Table 3-4). This decrease is attributable to three general changes.[1] First, the decrease is attributable to the installation of flue gas desulfurization controls at new coal-fired electric generating stations and a reduction in the average sulfur content of fuels consumed over the 10-year period. Second, emissions from industrial processes have declined, primarily as the result of controls implemented to reduce emissions from nonferrous smelters and sulfuric acid manufacturing plants, as well as shutdowns of some large smelters. Finally, emissions from other stationary source fuel combustion sectors also declined, mainly due to decreased combustion of coal by these consumers.

A small (1 percent) increase in sulfur oxides emissions between 1988 and 1989 can be attributed to increased electric generation.

The disparity between the 24 percent improvement in SO_2 air quality and the 10 percent decrease in SOx emissions can be attributed to several factors. SO_2 monitors with sufficient historical data for trends are mostly urban population-oriented. They do not monitor many of the major emitters which tend to be located in more rural areas (e.g. large power plants).

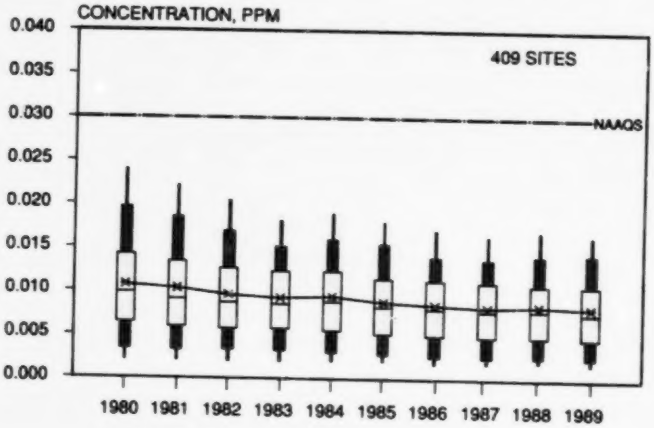


Figure 3-13. Boxplot comparisons of trends in annual mean sulfur dioxide concentrations at 409 sites, 1980-1989.

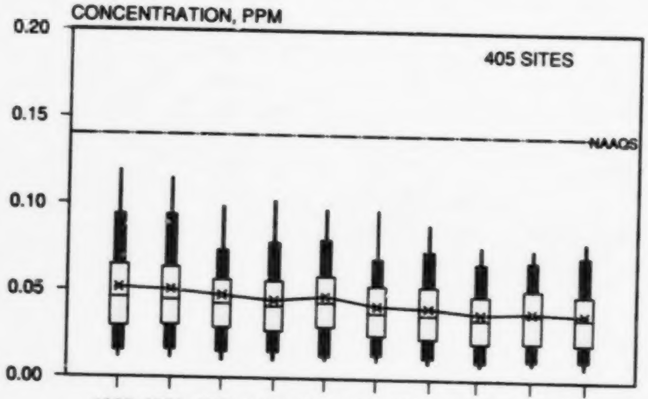


Figure 3-14. Boxplot comparisons of trends in second highest 24-hour average sulfur dioxide concentrations at 405 sites, 1980-1989.

Although most of the trend sites are categorized as population-oriented, the majority of SOx emissions are dominated by large point sources. Two-thirds of all national SOx emissions are generated by electric utilities (95 percent of which come from coal fired power plants). The majority of these emissions, however, are produced by a small number of facilities. Fifty individual plants in 15 states account for one-half of all power plant emissions. In addition, the 200 highest SOx emitters account for more than 85 percent of all SOx power plant emissions. These 200 plants account for 59 percent of all SOx emissions nationally.[9]

Another factor which may account for differences in SOx emissions and ambient air quality is stack height. At large utilities and smelters, SO_2 is generally released into the atmosphere through tall stacks. Although sources are not permitted to increase emissions through increased dispersion from tall stacks, measured ground level

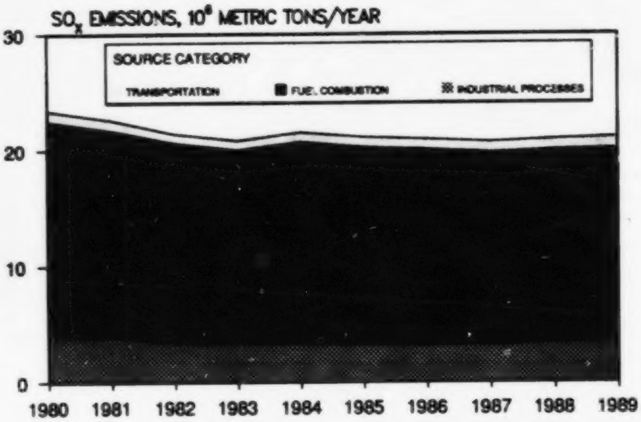


Figure 3-15. National trend in sulfur oxides emissions, 1980-1989.

TABLE 3-4. NATIONAL SULFUR OXIDES EMISSION ESTIMATES, 1980-1989

(million metric tons/year)										
SOURCE CATEGORY	**1980**	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**
Transportation	0.9	0.9	0.8	0.8	0.8	0.9	0.9	0.9	0.9	1.0
Fuel Combustion	18.7	17.8	17.3	16.7	17.4	17.0	16.9	16.6	16.6	16.8
Industrial Processes	3.8	3.9	3.3	3.3	3.3	3.2	3.2	3.2	3.4	3.3
Solid Waste	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Miscellaneous	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	23.4	22.6	21.4	20.7	21.5	21.1	20.9	20.7	20.9	21.1

NOTE: The sums of sub-categories may not equal total due to rounding.

concentrations in the vicinity of these exixting sources may not reflect local emissions. Total atmospheric loading impacts also arise, in part, as a consequence of tall stacks.

3.2.2 Recent SO_2 Trends: 1987-89

Nationally, SO_2 showed minor changes over the last three years. Composite average concentrations increased 3 percent between 1987 and 1988 and then decreased a little over 3 percent between 1988 and 1989. Regional changes in composite annual average SO_2 concentrations for the last 3 years, 1987-1989, are shown in Figure 3-16. Most Regions show little change among the last 3 years, with the exception of Region X, which shows a large decrease since 1987. This was the result of lower monitored concentrations in the vicinity of State of Washington pulp mills.

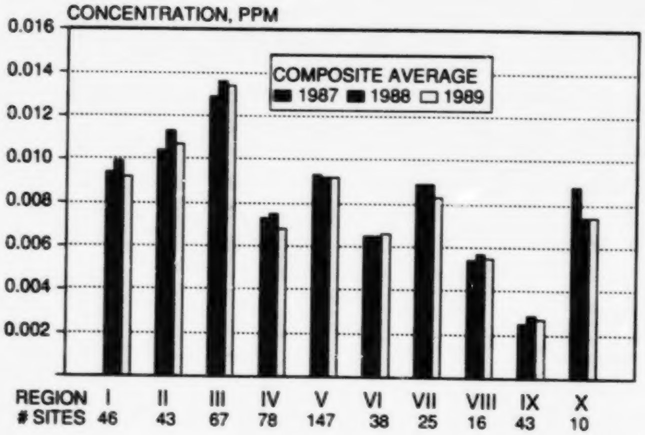


Figure 3-16. Regional comparisons of the 1987, 1988, 1989 composite averages of the annual average sulfur dioxide concentration.

3.3 TRENDS IN CARBON MONOXIDE

Carbon monoxide (CO) is a colorless, odorless and poisonous gas produced by incomplete burning of carbon in fuels. Two-thirds of the nationwide CO emissions are from transportation sources, with the largest contribution coming from highway motor vehicles. The NAAQS for ambient CO specify upper limits for both 1-hour and 8-hour averages that are not to be exceeded more than once per year. The 1-hour level is 35 ppm, and the 8-hour level is 9 ppm. This trends analysis focuses on the 8-hour average results because the 8-hour standard is generally the more restrictive limit. Nationally, during 1989, only three exceedances of the CO 1-hour NAAQS were recorded at two sites which are impacted by localized, non-mobile sources, and in each case the 8-hour NAAQS was still the controlling standard.

Carbon monoxide enters the bloodstream and disrupts the delivery of oxygen to the body's organs and tissues. The health threat is serious for those who suffer from cardiovascular disease, particularly those with angina or peripheral vascular disease. Exposure to elevated carbon monoxide levels is associated with impairment of visual perception, manual dexterity, learning ability and performance of complex tasks.

Trends sites were selected using the procedures presented in Section 2.1 which yielded a data base of 280 sites for the 10-year period 1980-89 and a data base of 355 sites for the 3-year 1987-89 period. There were 87 NAMS sites included in the 10-year data base and 103 NAMS sites in the 3-year data base.

3.3.1 Long-term CO Trends: 1980-89

The 1980-89 composite national average trend is shown in Figure 3-17 for the second highest non-overlapping 8-hour CO concentration for the 280 long-term trend sites and the subset of 87 NAMS sites. During this 10-year period, the national composite average decreased by 25 percent and the subset of NAMS decreased by 28 percent. The median rate of improvement for this time period is slightly more than 3 percent per year. After leveling off to no significant change from 1985 to 1986, the trend resumed downward in 1987 and later years. Long-term improvement was seen in each EPA Region with median rates of improvement varying from 2 to 5 percent per year. The 1989 composite average is significantly lower than the composite means for 1986 and earlier years. This same trend is shown in Figure 3-18 by a boxplot presentation which provides more information on the year-to-year distribution of ambient CO levels at the 280 long-term trend sites. While there is some year to year fluctuation in certain percentiles, the general long-term improvement in ambient CO levels is clear.

Figure 3-19 displays the 10-year trend in the composite average of the estimated number of exceedances of the 8-hour CO NAAQS. This exceedance rate was adjusted to account for incomplete sampling. The trend in exceedances shows long-term improvement but the rates are much higher than those for the second maximums. The composite average of estimated exceedances decreased 80 percent between 1980 and 1989 for the 280 long-term trend sites, while the subset of 87 NAMS showed a 77 percent decrease. These percentage changes for exceedances are typically much larger than those found for peak concentrations, such as the annual second maximum 8-hour value, which is more likely to reflect the change in emission levels. The upturns in the composite average of the estimated exceedances between 1987 and 1988, and between 1988 and 1989 are not statistically significant, and are not evident in the larger 3-year data base.

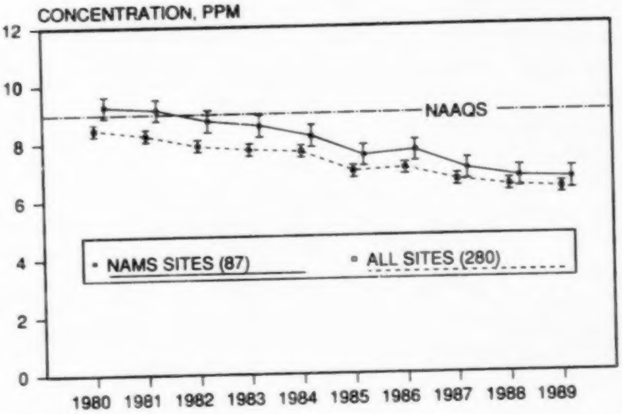


Figure 3-17. National trend in the composite average of the second highest nonoverlapping 8-hour average carbon monoxide concentration at both NAMS and all sites with 95 percent confidence intervals, 1980-1989.

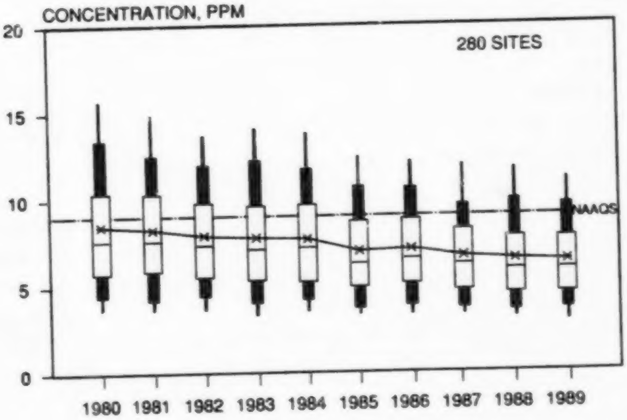


Figure 3-18. Boxplot comparisons of trends in second highest nonoverlapping 8-hour average carbon monoxide concentrations at 280 sites, 1980-1989.

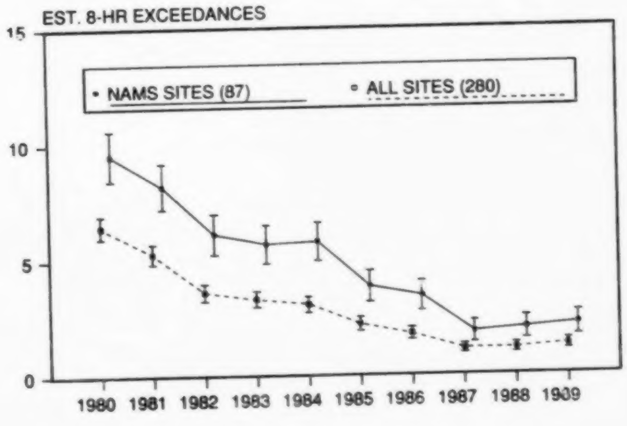


Figure 3-19. National trend in the composite average of the estimated number of exceedances of the 8-hour carbon monoxide NAAQS, at both NAMS and all sites with 95 percent confidence intervals, 1980-1989.

The 10-year 1980-89 trend in national carbon monoxide emission estimates is shown in Figure 3-20 and in Table 3-5. These estimates show a 23 percent decrease between 1980 and 1989. Transportation sources accounted for approximately 70 percent of the total in 1980 and decreased to 66 percent of total emissions in 1989. Emissions from highway vehicles decreased 33 percent during the 1980-89 period, despite a 39 percent increase in vehicle miles of travel.[1] Figure 3-21 contrasts the 10 year increasing trend in vehicle miles travelled (VMT) with the declining trend in carbon monoxide emissions from highway vehicles. This indicates that the Federal Motor Vehicle Control Program (FMVCP) has been effective on the national scale, with controls more than offsetting growth during this period. While there is general agreement between changes in air quality and emissions over this 10-year period, it is worth noting that the emission changes reflect estimated

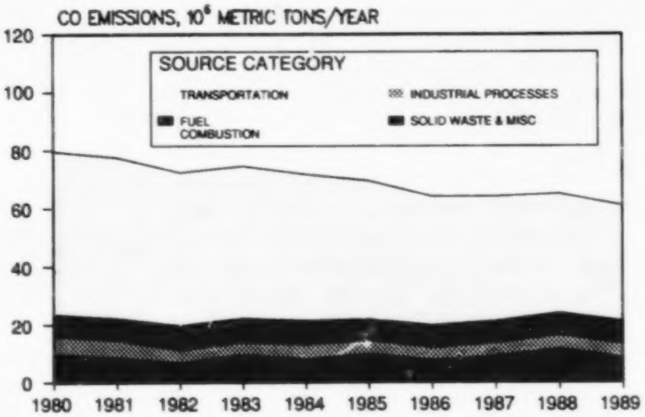


Figure 3-20. National trend in emissions of carbon monoxide, 1980-1989.

TABLE 3-5. NATIONAL CARBON MONOXIDE EMISSION ESTIMATES, 1980-1989

(million metric tons/year)										
SOURCE CATEGORY	**1980**	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**
Transportation	56.1	55.4	52.9	52.4	50.6	47.9	44.6	43.3	41.2	40.0
Fuel Combustion	7.4	7.7	8.2	8.2	8.3	7.5	7.5	7.6	7.6	7.8
Industrial Processes	6.3	5.9	4.3	4.3	4.7	4.4	4.2	4.3	4.6	4.6
Solid Waste	2.2	2.1	2.0	1.9	1.9	1.9	1.8	1.8	1.7	1.7
Miscellaneous	7.6	6.4	4.9	7.7	6.3	7.9	5.9	7.2	9.9	6.7
TOTAL	79.6	77.4	72.4	74.5	71.8	69.6	64.0	64.2	65.0	60.9

NOTE: The sums of sub-categories may not equal total due to rounding.

national totals, while ambient CO monitors are frequently located to identify problems. The mix of vehicles and the change in vehicle miles of travel in the area around a specific CO monitoring site may differ from the national averages.

Despite the progress that has been made, CO remains a concern in many urban areas. The characterization of the CO problem is complicated because of the growth and possible changes in traffic patterns that have occurred in many major urban areas. There are a variety of possible factors to consider, such as topography, meteorology, and localized traffic flow. The goal is to ensure that the monitoring networks continue to characterize the ambient CO problem adequately. However, these concerns should not overshadow the genuine progress documented over time in areas that have traditionally been the focus of the CO problem. Figure 3-22 demonstrates the progress that has been made in reducing carbon monoxide levels in Denver following implementation of local and Federal control measures.

Figure 3-23 displays the 10-year trend among MSAs of varying population size. Only those sites meeting the ten-year trends data completeness and continuity criteria were included in the analysis. Three size categories are shown: 27 moderate-sized MSAs with populations of 250 to 500 thousand; 35 large MSAs with populations between 500 thousand and one million; and 43 very-large MSAs with populations greater than one million. The composite means are generally higher in the very-large MSAs, although the patterns are mixed for some years. The moderate and large MSAs had 1989 composite average second highest nonoverlapping 8-hour concentrations 22 percent lower than 1980 levels. The 43 MSAs with populations greater than one million recorded a 25 percent decrease during

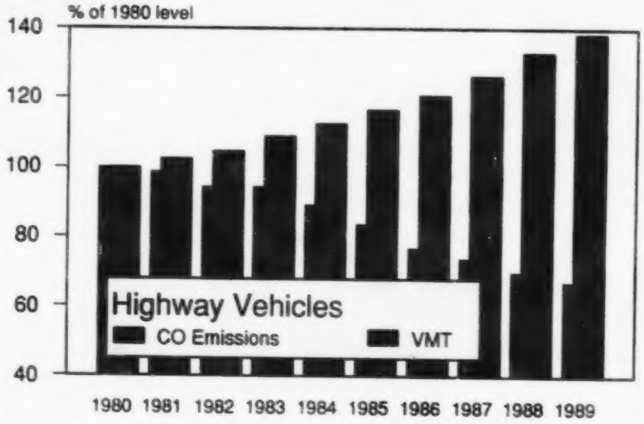
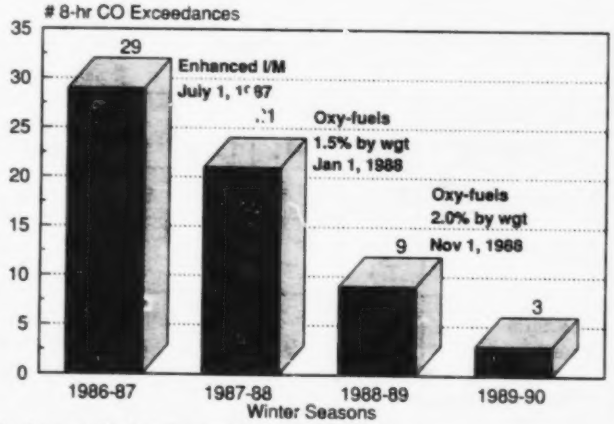


Figure 3-21. Comparison of trends in total national vehicle miles traveled and national highway vehicle emissions, 1980-1989.



Implementation of Local and Federal Control Measures - I/M, Oxy-Fuel, FMVCP

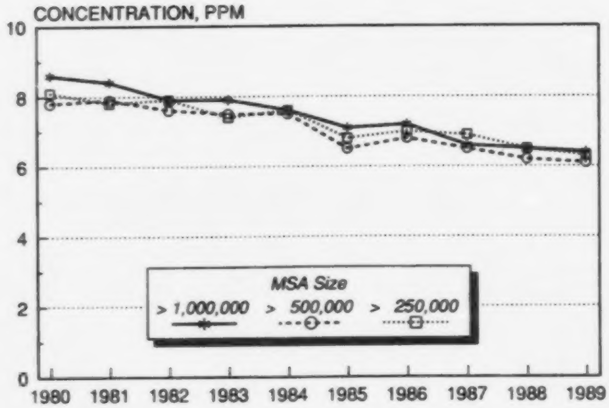
Figure 3-22. Decrease in carbon monoxide exceedances in Denver, Colorado.

this 10-year period. Between 1988 and 1989, the composite average decreased 3 percent for the moderate-sized MSAs, 2 percent for the large MSAs and less than 1 percent for the very large metropolitan complexes.

3.3.2 Recent CO Changes

This section examines ambient CO changes during the last 3 years, 1987-89. As discussed in Section 2.1, this allows the use of a larger data base, 355 versus 280 sites. Between 1988 and 1989, the composite average of the second highest non-overlapping 8-hour average concentration at 355 sites decreased by 1 percent and by less than 1 percent at the 103 NAMS sites. The composite average of the estimated number of exceedances of the 8-hour CO NAAQS at the 355 sites decreased by less than 1 percent between 1988 and 1989. Estimated nationwide CO emissions decreased 6 percent between 1988 and 1989. Part of this decrease is attributed to a 4 percent reduction in CO emissions from highway vehicles. A larger part, however, is due to higher than normal forest fire activity in 1988.

Figure 3-24 shows the composite Regional averages for the 1987-89 time period. Five of the 10 Regions have 1989 composite mean levels lower than their 1988 values and five are higher in 1989. Every Region, except Region IX, have 1989 composite mean levels less than the corresponding 1987 value. These Regional graphs are primarily intended to depict relative change. Because the mix of monitoring sites may vary from one area to another, this graph is not intended to indicate Regional differences in absolute concentration levels.



Note: 1987 MSA population estimates

Figure 3-23. Metropolitan area trends in the composite average of the second highest non-overlapping 8-hour average carbon monoxide concentration, 1980-1989.

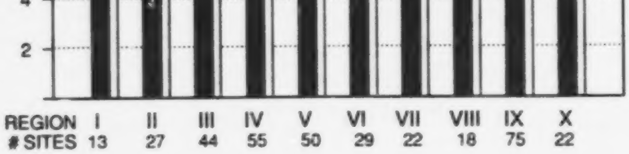


Figure 3-24. Regional comparisons of the 1987, 1988 and 1989 composite averages of the second highest non-overlapping 8-hour average carbon monoxide concentration.

3.4 TRENDS IN NITROGEN DIOXIDE

Nitrogen dioxide (NO_2) is a yellowish brown, highly reactive gas which is present in urban atmospheres. The major mechanism for the formation of NO_2 in the atmosphere is the oxidation of the primary air pollutant, nitric oxide (NO). Nitrogen oxides play a major role, together with volatile organic compounds, in the atmospheric reactions that produce ozone. Nitrogen oxides form when fuel is burned at high temperatures. The two major emissions sources are transportation and stationary fuel combustion sources such as electric utility and industrial boilers.

Nitrogen oxides can irritate the lungs, cause bronchitis and pneumonia, and lower resistance to respiratory infections. Los Angeles, CA is the only urban area that has recorded violations of the annual NO_2 standard of 0.053 ppm during the past 10 years.

NO_2 is measured using a continuous monitoring instrument which can collect as many as 8760 hourly observations per year. Only annual means based on at least 4380 hourly observations were considered in the trends analyses which follow. A total of 148 sites were selected for the 10-year period and 200 sites were selected for the 3-year data base.

3.4.1 Long-term NO_2 Trends: 1980-89

The composite average long-term trend for the nitrogen dioxide mean concentrations at the 148 trend sites and the 36 NAMS sites, is shown in Figure 3-25. The 95 percent confidence intervals about the composite means allow for comparisons among the years. Nationally, composite annual average NO_2 levels decreased from 1980 to 1983, and remained essentially constant since 1984. The 1989 composite average NO_2 level is 5 percent lower than the 1980 level, indicating an overall downward trend during this period. A similar trend is seen for the NAMS sites which, for NO_2, are located only in urban areas with populations of 1,000,000 or greater. As expected, the composite averages of the NAMS are higher than those of all sites, however, they also recorded a 5 percent decrease in composite mean levels during this

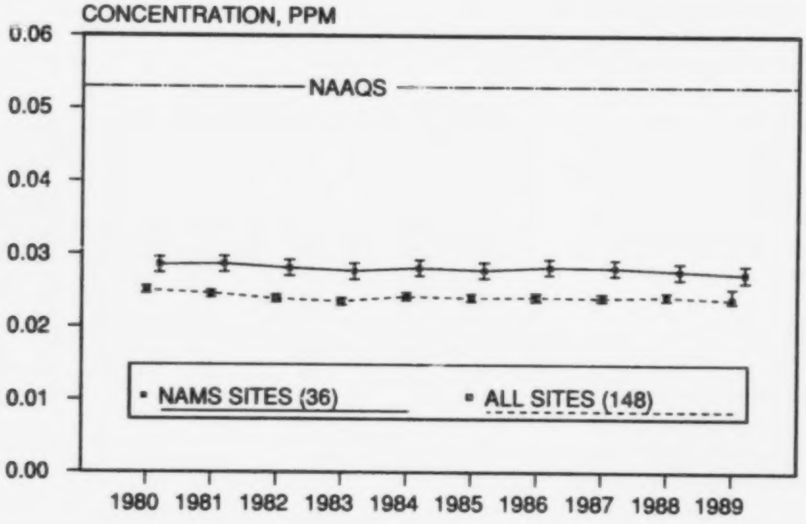


Figure 3-25. National trend in the composite annual average nitrogen dioxide concentration at both NAMS and all sites with 95 percent confidence intervals, 1980-1989.

period. Although the 1989 composite mean levels are 5 percent lower than the 1980 means, an examination of the confidence intervals reveals that there are no significant differences among all years, for all sites and for the subset of NAMS.

Long-term trends in NO_2 annual average concentrations are also displayed in Figure 3-26 with the use of boxplots. The improvement in the composite average between 1980 and 1989 can generally be seen in the upper percentiles until 1984, with mixed results in the following years. The lower percentiles show little change, however.

Figure 3-27 displays the 10-year trend among MSAs of varying population size. Only those sites meeting the ten-year trends data completeness and continuity criteria were included in the analysis. As expected, there are fewer MSAs for NO_2 in each size category than for carbon monoxide, because NO_2 monitoring is only required in large cities. Three size categories are shown: 16 moderate-sized MSAs with populations of 250 to 500 thousand; 14 large MSAs with populations between 500 thousand and one million; and 30 very-large MSAs with populations greater than one million. Unlike carbon monoxide, the level of the NO_2 composite means varies directly with MSA size, the larger the population the higher the concentration level. Although the pattern of the year-to-year changes differs somewhat among MSA size, the long-term trend is consistent across MSA size category with 1989 composite mean levels 6 percent lower than 1980 levels.

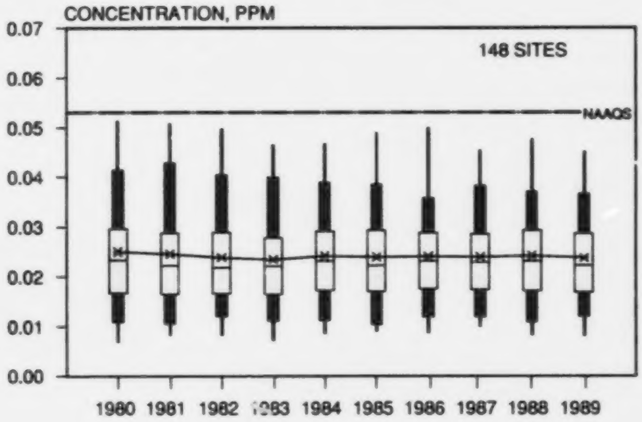
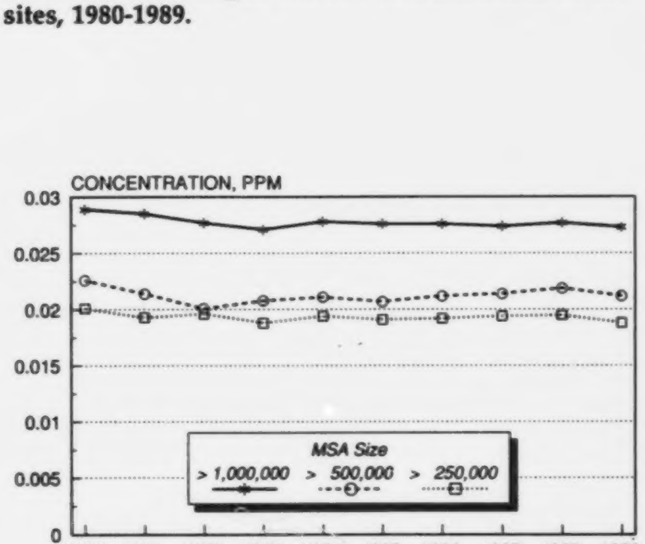


Figure 3-26. Boxplot comparisons of trends in annual mean nitrogen dioxide concentrations at 148 sites, 1980-1989.



Note: 1987 MSA population estimates

Figure 3-27. Metropolitan area trends in the composite annual average nitrogen dioxide concentration, 1980-1989.

Table 3-6 presents the trend in estimated nationwide emissions of nitrogen oxides (NOx). The decreasing trend in NOx emissions from 1980 through 1983 was reversed in 1984. The decline in NOx nationwide emissions between 1985 and 1986 has been followed by increased NOx emissions in 1987 and 1988. However, total 1989 nitrogen oxides emissions are 5 percent less than 1980 emissions. Highway vehicle emissions decreased by 25 percent during this period, while fuel combustion emissions have increased during the last 3 years. Figure 3-28 shows that the two primary source categories of nitrogen oxides emissions are fuel combustion and transportation, composing 56 percent and 40 percent, respectively, of total 1989 nitrogen oxides emissions.

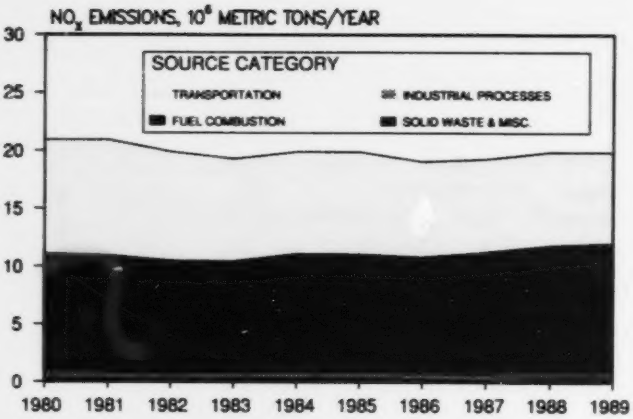


Figure 3-28. National trend in nitrogen oxides emissions, 1980-1989.

TABLE 3-6. NATIONAL NITROGEN OXIDES EMISSION ESTIMATES, 1980-1989

	(million metric tons/year)									
SOURCE CATEGORY	**1980**	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**
Transportation	9.8	10.0	9.4	8.9	8.8	8.9	8.3	8.1	8.1	7.9
Fuel Combustion	10.1	10.0	9.8	9.6	10.2	10.2	10.0	10.5	10.9	11.1
Industrial Processes	0.7	0.6	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6
Solid Waste	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Miscellaneous	0.2	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.3	0.2
TOTAL	20.9	20.9	20.0	19.3	19.8	19.9	19.1	19.4	20.0	19.9

NOTE: The sums of sub-categories may not equal total due to rounding.

3.4.2 Recent NO_2 Changes

Between 1988 and 1989, the composite annual mean NO_2 concentration at 200 sites, with complete data during the last three years, decreased by 2 percent. At the subset of 47 NAMS, the composite mean concentration decreased 1 percent between 1988 and 1989. Nationwide emissions of nitrogen oxides decreased 1 percent between 1988 and 1989.

Regional trends in the composite average NO_2 concentrations for the years 1987-89 are displayed in Figure 3-29 with bar graphs. Region X, which did not have any NO_2 sites which met the 3-year data completeness and continuity criteria, is not shown. Since the national trend shows no significant change during this period, the mixed pattern of the Regional year-to-year changes is not surprising. Between 1987 and 1988, three Regions had increased levels, three decreased, and three remained unchanged. The downturn seen in the long-term data base in also found in the larger 3-year data base. Seven of the nine Regions have 1989 composite mean concentrations which are lower than the corresponding 1988 levels. Region V and Region VII recorded increases of 2 percent and 1 percent, respectively.

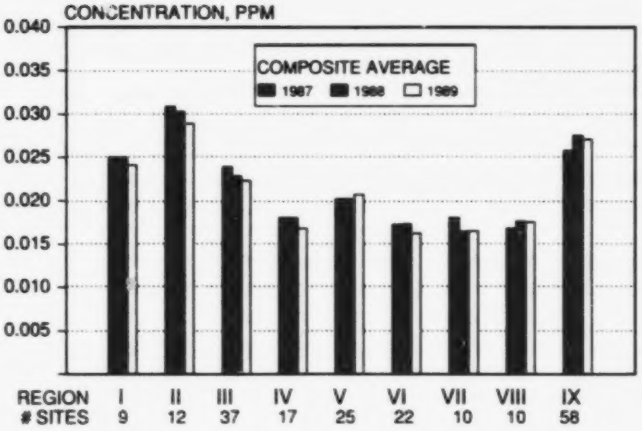


Figure 3-29. Regional comparisons of 1987, 1988, 1989 composite averages of the annual mean nitrogen dioxide concentration.

3.5 TRENDS IN OZONE

Ozone (O_3) is a photochemical oxidant and the major component of smog. While ozone in the upper atmosphere is beneficial to life by shielding the earth from harmful ultraviolet radiation from the sun, high concentrations of ozone at ground level are a major health and environmental concern. Ozone is not emitted directly into the air but is formed through complex chemical reactions between precursor emissions of volatile organic compounds and nitrogen oxides in the presence of sunlight. These reactions are stimulated by sunlight and temperature so that peak ozone levels occur typically during the warmer times of the year. Both volatile organic compounds and nitrogen oxides are emitted by transportation and industrial sources. Volatile organic compounds are emitted from sources as diverse as autos, chemical manufacturing, and dry cleaners, paint shops and other sources using solvents. Nitrogen oxides emissions were discussed in Section 3.4.

The reactivity of ozone causes health problems because it tends to break down biological tissues and cells. Recent scientific evidence indicates that high levels of ozone not only affect people with impaired respiratory systems, such as asthmatics, but healthy adults and children, as well. Exposure to ozone for only several hours at relatively low concentrations has been found to significantly reduce lung function in normal, healthy people during exercise. This decrease in lung function generally is accompanied by symptoms including chest pain, coughing, sneezing and pulmonary congestion.

The O_3 NAAQS is defined in terms of the daily maximum, that is, the highest hourly average for the day, and it specifies that the expected number of days per year with values greater than 0.12 ppm should not be greater than one. Both the annual second highest daily maximum and the number of daily exceedances during the ozone season are considered in this analysis. The strong seasonality of ozone levels makes it possible for areas to limit their ozone monitoring to a certain portion of the year, termed the ozone season. The length of the ozone season varies from one area of the country to another. May through October is typical but states in the south and southwest may monitor the entire year. Northern States would have shorter ozone seasons such as May through September for

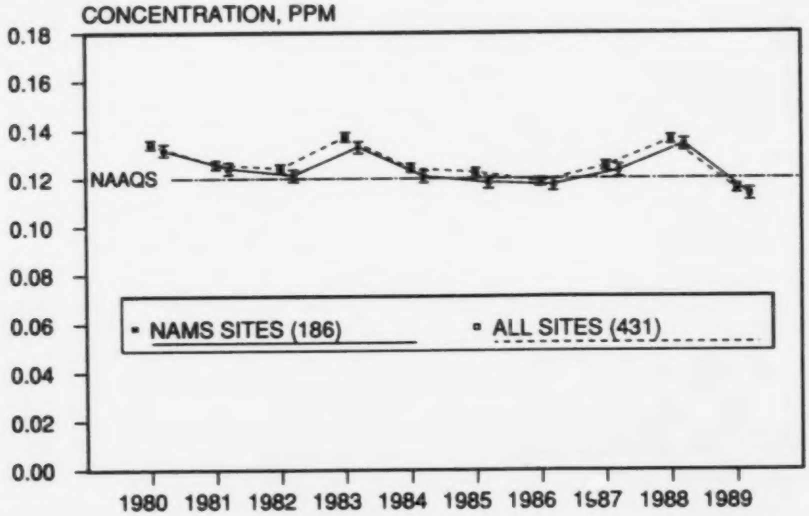


Figure 3-30. National trend in the composite average of the second highest maximum 1-hour ozone concentration at both NAMS and all sites with 95 percent confidence intervals, 1980-1989.

North Dakota. This analysis uses these ozone seasons to ensure that the data completeness requirements apply to the relevant portions of the year.

The trends site selection process, discussed in Section 2.1, resulted in 431 sites being selected for the 1980-89 period, an increase of 43 sites (or 11%) from the 1979-88 trends data base. A total of 581 sites are included in the 1987-89 data base. The NAMS compose 186 of the long-term trends sites and 208 of the sites in the 3-year data base.

3.5.1 Long-term O_3 Trends: 1980-89

Figure 3-30 displays the 10-year composite average trend for the second highest day during the ozone season for the 431 trends sites and the subset of 186 NAMS sites. The 1989 composite average for the 431 trend sites is 14 percent lower than the 1980 average, yielding the lowest composite average of the past ten years. The 1989 composite average is significantly less than the 1988 composite mean, which is the second highest average (1983 was the highest) during this ten year period. The relatively high ozone concentrations in both 1983 and 1988 are likely attributed in part to hot, dry, stagnant conditions in some areas of the country that were more conducive to ozone formation than other years. Meteorological conditions in the summer of 1989 were less conducive to ozone formation than 1983 and 1988. In the East, the period from January through July 1989 was among the wettest on record in nine states.[10]

The inter-site variability of the annual second highest daily maximum concentrations for the 431 site data base is displayed in Figure 3-31. The years 1980, 1983 and 1988 values are similarly high, while the remaining years in the 1980-89 period are generally lower, with

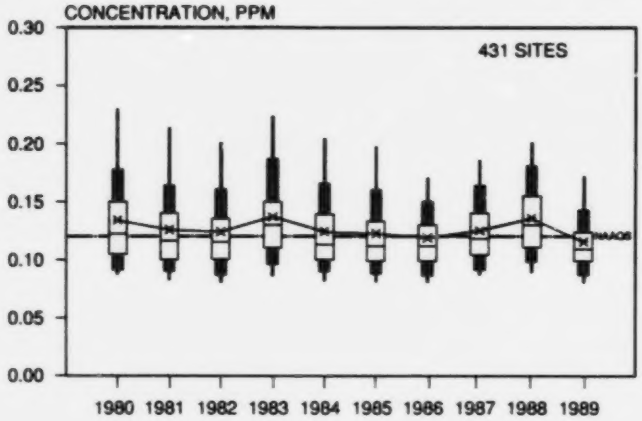


Figure 3-31. Boxplot comparisons of trends in annual second highest daily maximum 1-hour ozone concentration at 431 sites, 1980-1989.

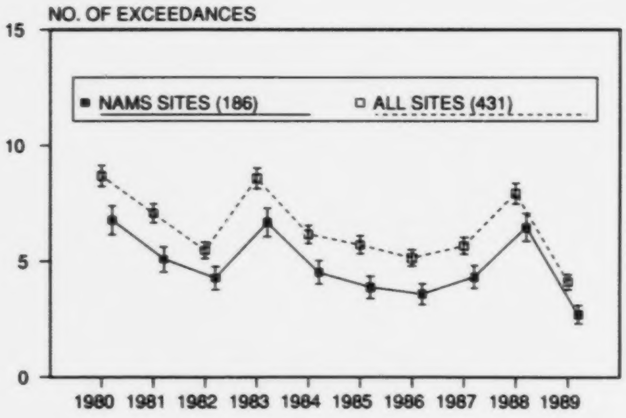
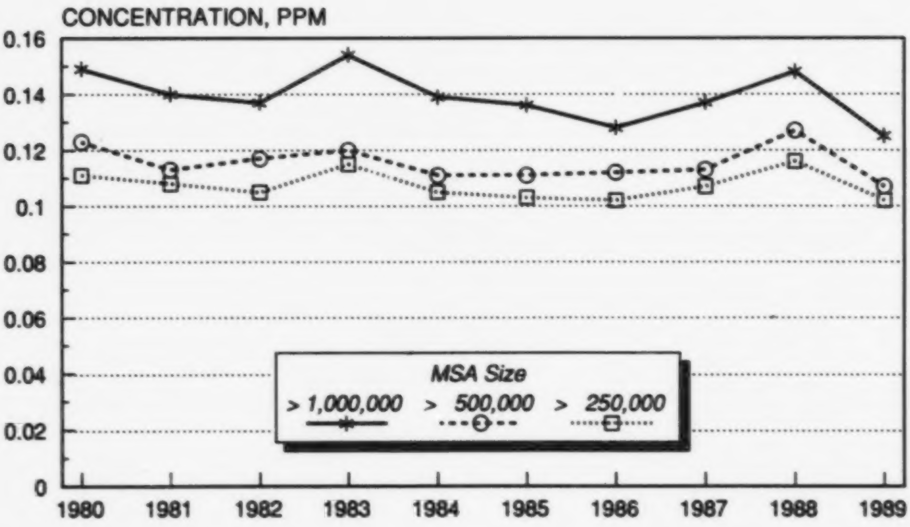


Figure 3-32. National trend in the estimated number of daily exceedances of the ozone NAAQS in the ozone season at both NAMS and all sites with 95 percent confidence intervals, 1980-1989.

1989 being the lowest, on average. The distribution of second daily maximum 1-hour concentrations in 1989 is similar to that recorded in 1986. The 1987 ozone concentration distribution is comparable to 1984 and 1985 except for the peak sites, which were considerably lower than these earlier years. Figure 3-32 depicts the 1980-89 trend for the composite average number of ozone exceedances. This statistic is adjusted for missing data, and it reflects the number of days that the ozone standard is exceeded during the ozone season. Since 1980, the expected number of exceedances decreased 53 percent for the 431 sites and 60 percent for the 186 NAMS. As with the second maximum, the 1980, 1983 and 1988 values are higher than the other years in the 1980-89 period. The endpoints of this ten year period represent the two extremes, with the 1980 composite average of the number of estimated exceedances being the highest level during the last ten years, and 1989 the lowest.

Figure 3-33 displays the 10-year trend in the composite average of the second daily maximum 1-hour concentrations among MSAs of varying population size. Only those sites meeting the ten-year trends data completeness and continuity criteria were included in the analysis. Three size categories are shown: 40 moderate-sized MSAs with populations of 250 to 500 thousand; 34 large MSAs with populations between 500 thousand and one million; and 37 very-large MSAs with populations greater than one million. The magnitude of the ozone composite averages of the second daily maximum 1-hour concentrations varies directly with MSA size, the larger the population the higher the concentration level. Although the pattern of the year-to-year changes is similar among MSA size, the long-term trend varies across MSA size category. The 1989 composite mean in the very-large MSAs is 16 percent lower than 1980 level, 13 percent lower for the large MSAs and 8 percent lower for the medium-sized MSAs.



Note: 1987 MSA population estimates

Figure 3-33. Metropolitan area trends in the composite average of the second highest maximum 1-hour ozone concentration, 1980-1989.

Table 3-7 and Figure 3-34 display the 1980-89 emission trends for volatile organic compounds (VOC) which, along with nitrogen oxides, are involved in the atmospheric chemical and physical processes that result in the formation of O_3. Total VOC emissions are estimated to have decreased 19 percent between 1980 and 1989. Between 1980 and 1989, VOC emissions from highway vehicles are estimated to have decreased 34 percent, despite a 39 percent increase in vehicle miles of travel during this time period (see Figure 3-21). Previously, VOC emissions from highway vehicles were estimated using nationwide annual temperatures and nationwide average Reid Vapor Pressure (RVP). The new estimates are based on statewide average monthly temperatures and statewide RVP. Emissions from forest fires have also been revised. The net result is that the new estimate for 1988 is 5 percent higher than the estimate presented in last year's report.

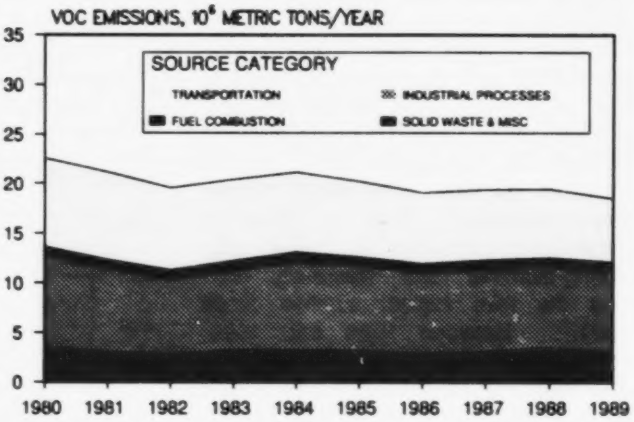


Figure 3-34. National trend in emissions of volatile organic compounds, 1980-1989.

TABLE 3-7. NATIONAL VOLATILE ORGANIC COMPOUND EMISSION ESTIMATES, 1980-1989

	(million metric tons/year)									
SOURCE CATEGORY	**1980**	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**
Transportation	9.0	8.9	8.3	8.2	8.1	7.6	7.2	7.1	6.9	6.4
Fuel Combustion	0.9	0.9	1.0	1.0	1.0	0.9	0.9	0.9	0.9	0.9
Industrial Processes	9.2	8.3	7.5	7.9	8.8	8.5	8.1	8.3	8.1	8.1
Solid Waste	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Miscellaneous	2.9	2.5	2.2	2.7	2.7	2.6	2.3	2.5	2.9	2.5
TOTAL	22.7	21.3	19.5	20.3	21.1	20.2	19.1	19.4	19.5	18.5

NOTE: The sums of sub-categories may not equal total due to rounding.

3.5.2 Recent O_3 Changes

This section discusses ambient O_3 changes during the 3-year time period 1987-89. Using this 3-year period permits the use of a larger data base of 581 sites, compared to 431 for the 10-year period. The composite average at these 581 sites increased 8 percent from 1987 to 1988, likely due to the hot, dry meteorological conditions experienced in much of the Eastern U.S. during Summer 1988. Nationally, 1988 was the third hottest summer since 1931.[11] Between 1988 and 1989, composite mean ozone concentrations decreased 15 percent at the 581 sites and 16 percent at the subset of 208 NAMS. The interpretation of recent trends is difficult due to the confounding factors of meteorology and emission changes. Just as the increase in 1988 is attributed in part to meteorological conditions, the 1989 decrease is likely due, in part, to meteorological conditions being less favorable for ozone formation in 1989 than in 1988. Also, new regulations lowered national average summertime RVP in regular unleaded gasoline from 10.0 to 8.9 psi between 1988 and 1989.[12,13,14] Between 1988 and 1989, the composite average of the number of estimated exceedances of the ozone standard decreased by 49 percent at the 581 sites, and 53 percent at the 208 NAMS. Nationwide VOC emissions decreased 5 percent between 1988 and 1989.

Figure 3-35 uses boxplots to illustrate that the decrease in second daily maximum 1-hour ozone concentrations can be found across metropolitan areas of varying size. Between 1988 and 1989, the composite average decreased by 12 percent at 62 sites in 40 moderate-sized MSAs. A decrease of 16 percent in composite mean concentrations was recorded for both the large and very-large MSAs. Decreases in concentration levels can be found across all percentiles as well.

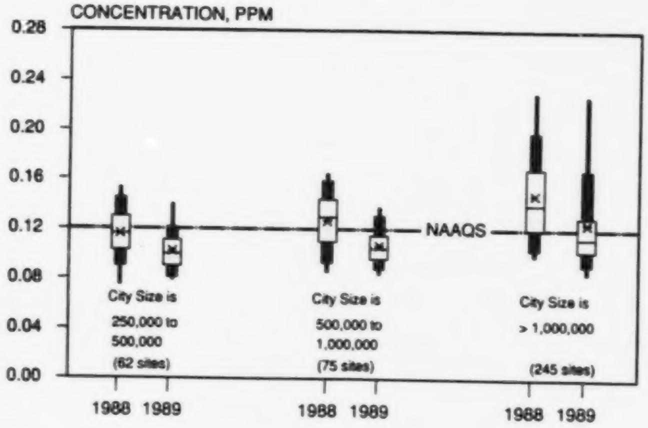


Figure 3-35. Boxplot comparison of recent changes in ozone second daily maximum 1-hour concentrations in metropolitan areas, 1988-1989.

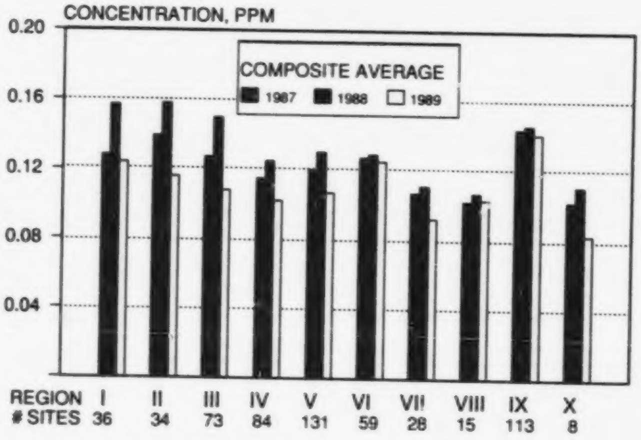


Figure 3-36. Regional comparisons of the 1987, 1988, 1989 composite averages of the second-highest daily 1-hour ozone concentrations.

The composite average of the second daily maximum concentrations increased in every region of the nation between 1987 and 1988. As Figure 3-36 indicates, the largest increases were recorded in the northeastern states, composing EPA Regions I through III. This pattern was reversed in 1989 with every Region recording lower composite average concentrations in 1989 than in 1988. The largest decreases are found in the Northeast.

Peak ozone concentrations typically occur during hot, dry, stagnant summertime conditions (high temperature and strong solar insolation).[15] Thus, studies have compared the variability in meteorological parameters such as maximum daily temperature, solar radiation, average daily wind speed and precipitation with the variability in peak ozone concentrations.[16] Figures 3-37 and 3-38, respectively, present summer 1987-89 data on the number of days greater than 90° F (directly related) and the number of days with precipitation (inversely related) for selected cities in each EPA Region.[17] Although the year-to-year changes in the meteorological parameters are similar to the changes in regional air quality (Figure 3-36), as shown later in Section 5, these simple indicators may not be sufficient to describe long-term trends in some cities.

3.5.3 Preview of 1990 Ozone Trends

In response to public concern and media attention during the summer of 1988, EPA initiated a cooperative program with the state and local air pollution control agencies for the early reporting of ozone summary data.[11] Preliminary, unvalidated data were reported to EPA approximately 3 to 4 months ahead of the schedule typically required for quality assurance and data submittal. Preliminary, unvalidated data and normally reported 1990 data have

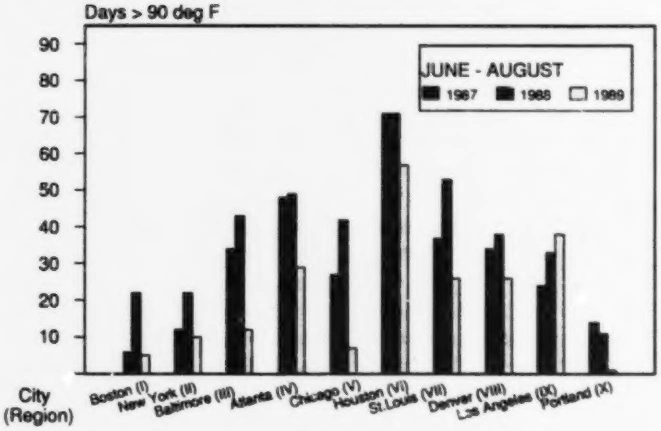


Figure 3-37. Regional comparisons of the number of days greater than 90°F in 1987, 1988, 1989 for selected cities.

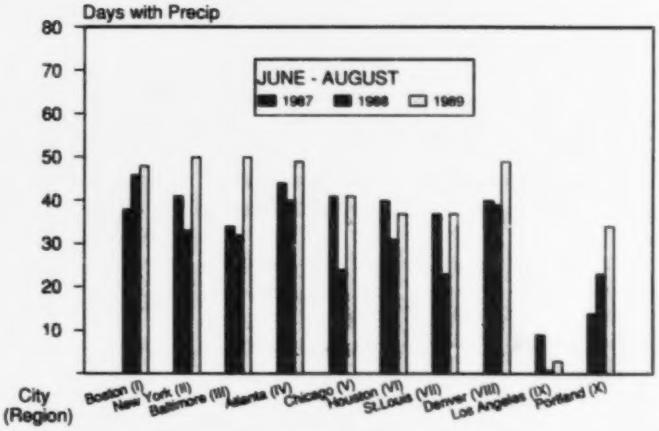


Figure 3-38. Regional comparisons of the number of days with precipitation in 1987, 1988, 1989 for selected cities.

been used here to provide a preliminary estimate of future ozone trends.

Summer 1990 temperature averaged across the nation was above the long-term mean and ranks as the 15th warmest summer on record since 1895.[18] Areally averaged precipitation was below the long-term mean and ranks as the 29th driest summer. Regionally, the Central and East North Central had average temperatures, with warmer rankings elsewhere. The South and Southeast were unusually dry, the Northeast, East, North Central and Northwest Regions were in the dry third of the distribution, and the rest of the nation was in the middle third of the distribution of yearly rankings.[18] Also, 1990 average RVP decreased 3 percent from summer 1989 levels.[19]

Figure 3-39 presents a preliminary estimate of the trend in the composite average of the annual daily maximum 1-hour concentration for the period 1980 through 1990. The 1990 composite average estimate is 1 percent lower than the 1989 level and is 16 percent lower than the 1988 level. This estimate is based on a subset of 337 of the 431 long-term trend sites and was adjusted for the mix of sites in the trends database. Although based on a larger number of sites than last year's preliminary 1989 estimate, this 1990 estimate should be viewed as preliminary, because summer 1990 data have not yet been subjected to the complete quality assurance process.

A preliminary estimate of the year-to-year changes among the Regions is shown in Figure 3-40. The preliminary 1990 composite mean concentrations are lower than the previous three years in 5 of the 10 Regions. Regions II through IV, and VI (the East, Southeast and Southwest) recorded similar, or slightly higher, levels than 1989, while Region X (the Northwest) recorded its highest composite mean concentration during the past 4 years.

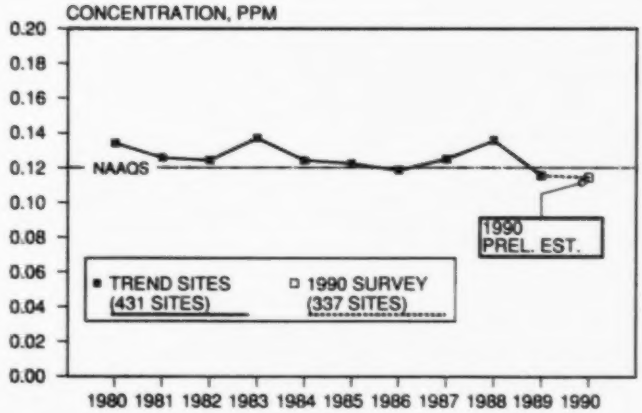


Figure 3-39. Preliminary estimate of the national trend in the composite average of the second highest daily maximum 1-hour ozone concentration, 1980-90.

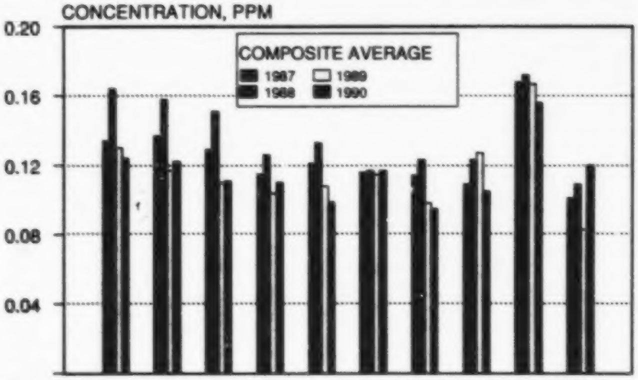


Figure 3-40. Regional comparisons of the 1987, 1988, 1989 and preliminary 1990 composite averages of the second-highest daily 1-hour ozone concentrations.

3.6 TRENDS IN LEAD

Lead (Pb) gasoline additives, nonferrous smelters and battery plants are the most significant contributors to atmospheric Pb emissions. Transportation sources in 1989 contributed 31 percent of the annual emissions, down substantially from 73 percent in 1985. Total lead emissions from all sources dropped from 21.1 x 10^3 metric tons in 1985 to 7.6 x 10^3 and 7.2 x 10^3 metric tons, respectively in 1988 and 1989. The decrease in lead emissions from highway vehicles accounts for essentially all of this drop. The reasons for this drop are noted below.

Two air pollution control programs implemented by EPA before promulgation of the Pb standard in October 1978[20] have resulted in lower ambient Pb levels. First, regulations issued in the early 1970s required gradual reduction of the Pb content of all gasoline over a period of many years. More recently, the Pb content of the leaded gasoline pool was reduced from an average of 1.0 grams/gallon to 0.5 grams/gallon on July 1, 1985 and still further to 0.1 grams/gallon on January 1, 1986. Second, as part of EPA's overall automotive emission control program, unleaded gasoline was introduced in 1975 for use in automobiles equipped with catalytic control devices. These devices reduce emissions of carbon monoxide, volatile organics and nitrogen oxides. In 1989, unleaded gasoline sales accounted for 89 percent of the total gasoline market - up from 82% in 1988. These programs have essentially eliminated violations of the lead standard in urban areas, except in those areas with lead point sources. Programs are also in place to control Pb emissions from stationary point sources. Pb emissions from stationary sources have been substantially reduced by control programs oriented toward attainment of the particulate matter and Pb ambient standards, however, significant ambient problems still remain around some lead point sources. Lead emissions in 1989 from industrial sources, e.g. primary and secondary lead smelters, dropped by more than one-half from levels reported in the late 70s. Emissions of lead from solid waste disposal are down 43 percent since the late 70s. In 1989, emissions from solid waste disposal and industrial processes (2.3 x 10^3 metric tons) represent the largest category of lead emissions just ahead of the 2.2 x 10^3 metric tons from transportation. The overall effect of these three control programs has been a major reduction in the amount of Pb in the ambient air.

3.6.1 Long-term Pb Trends: 1980-89

Early trend analyses of ambient Pb data[21,22] were based almost exclusively on National Air Surveillance Network (NASN) sites. These sites were established in the 1960's to monitor ambient air quality levels of TSP and associated trace metals, including Pb. The sites were predominantly located in the central business districts of larger American cities. In September 1981, ambient Pb monitoring regulations were promulgated.[23] The siting criteria in the regulations resulted in finding many of the old historic TSP monitoring sites unsuitable for the measurement of ambient Pb concentrations and many of the earlier sites were moved or discontinued.

As with the other pollutants, the sites selected for the long-term trend analysis had to satisfy annual data completeness criteria of at least 8 out of 10 years of data in the 1980 to 1989 period. A year was included as "valid" if at least 3 of the 4 quarterly averages were available. As in last year's report, composite lead data, i.e., individual 24-hour observations are composited together by month or quarter and a single analysis made, are being used in the trend analysis. Seventeen sites qualified for the 10-year trend because of the addition of composite data. A total of 189 urban-oriented sites, from 41 States, met the data completeness criteria. Forty-six of these sites were NAMS, the largest number of lead NAMS sites to qualify for the 10-year trends. Thirty-three (17 percent) of the 189 trend sites were located in the State of California, thus this State is over-represented in the sample of sites satisfying the long-term trend criteria. However, the lead trend at the California sites was almost identical to the trend at the non-California sites; so that these sites did not distort the overall trends. Sites that were located near lead point sources such as primary and secondary lead smelters were excluded from the urban trend analysis, because the magnitude of the levels at these sources could mask the underlying urban trends. Trends at lead point source oriented sites will be discussed separately in the next section.

The means of the composite maximum quarterly averages and their respective 95 percent confidence intervals are shown in Figure 3-41 for both the 189 urban sites and 46 NAMS sites (1980-1989). There was an 87 percent (1980-89) decrease in the average for the 189 urban sites. Lead emissions over this 10-year period also decreased. There was a 90 percent decrease in total lead emissions and a 96 percent decrease in lead emissions from transportation sources. The confidence intervals for these sites indicate that the 1985-89 averages are significantly less than all averages from preceding years. Because of the smaller number (46) of NAMS sites with at least 8 years of data, the confidence intervals are wider. However, the 1985-89 NAMS averages are still significantly different from all averages before 1985. It is interesting to note that the average lead concentrations at the NAMS sites in 1989 is essentially the same (0.073 µg/m^3) as the "all sites" average; whereas in the early 1980's the averages of the NAMS sites were significantly higher. Figure 3-42 shows the trend in average lead concentrations for the urban-oriented sites and for 19 point-source oriented sites which met the 10-year data completeness criteria. The improvement in average ambient lead concentrations at the point-source oriented sites, which are near industrial sources of lead, e.g. smelters, battery plants, is about the same on a percentage basis as the urban oriented sites. However, the average at the point-source oriented sites dropped in

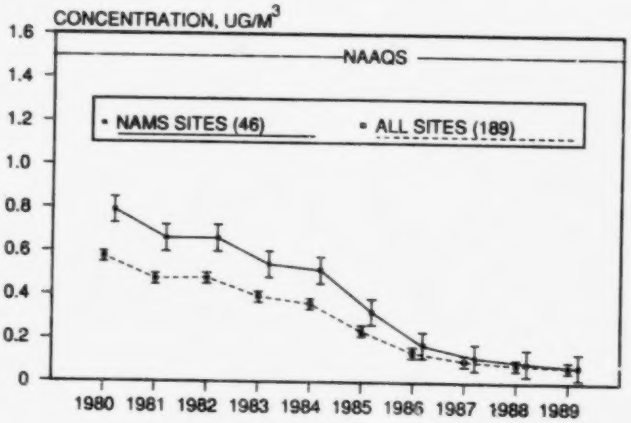


Figure 3-41. National trend in the composite average of the maximum quarterly average lead concentration at both NAMS and all sites with 95 percent confidence intervals, 1980-1989.

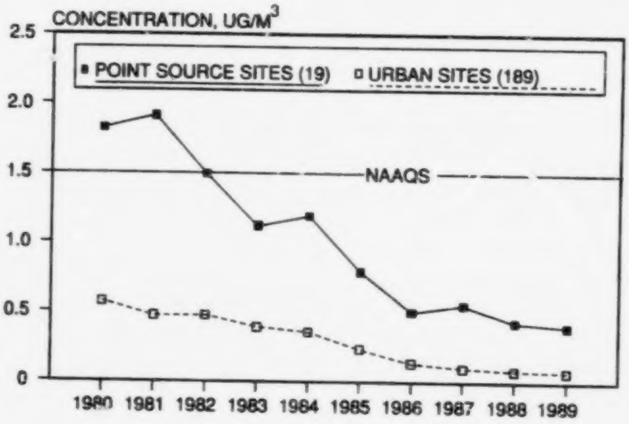


Figure 3-42. Comparison of national trend in the composite average of the maximum quarterly average lead concentrations at urban and point-source oriented sites, 1980-1989.

magnitude from 1.8 to 0.4 µg/m³, a 1.4 µg/m³ difference; whereas, the average at the urban site dropped only from 0.6 to 0.1 µg/m³. A site in Idaho, located near a shutdown smelter, with extremely high 1980-81 lead concentrations did not qualify for inclusion in this years 10-year data base but was in last years report. The result is that the 1980-89 change is now less pronounced than that shown last year for the point-source oriented sites. This improvement at the point-source oriented sites reflects both industrial and automotive lead emission controls, but in some cases, the industrial source reductions are because of plant shutdowns. The 4 MSA's shown in Table 4-3 that are above the lead NAAQS in 1989 are all caused by lead point sources. These MSA's are Birmingham Al, Dallas TX, Omaha NE-IA, and St Louis MO-IL. Figure 3-43 shows boxplot comparisons of the maximum quarterly average Pb concentrations at the 189 urban-oriented Pb trend sites (1980-89). This figure shows the dramatic improvement in ambient Pb concentrations for the entire distribution of trend sites. As with the composite average concentration since 1980, most of the percentiles also show a monotonically decreasing pattern. The 189 urban-oriented sites that qualified for the 1980-89 period, when compared to the 139 sites for 1979-88 and the 97 sites for 1978-87 period,[11] indicate a substantial expansion of the 10 year trends data base.

The trend in total lead emissions is shown in Figure 3-44. Table 3-8 summarizes the Pb emissions data as well. The 1980-89 drop in total Pb emissions was 90 percent. This compares with the 87 percent decrease (1980-89) in ambient lead concentrations. The drop in Pb consumption and subsequent Pb emissions since 1980 was brought about by the increased use of unleaded gasoline in catalyst-equipped cars and the reduced Pb content in leaded gasoline.

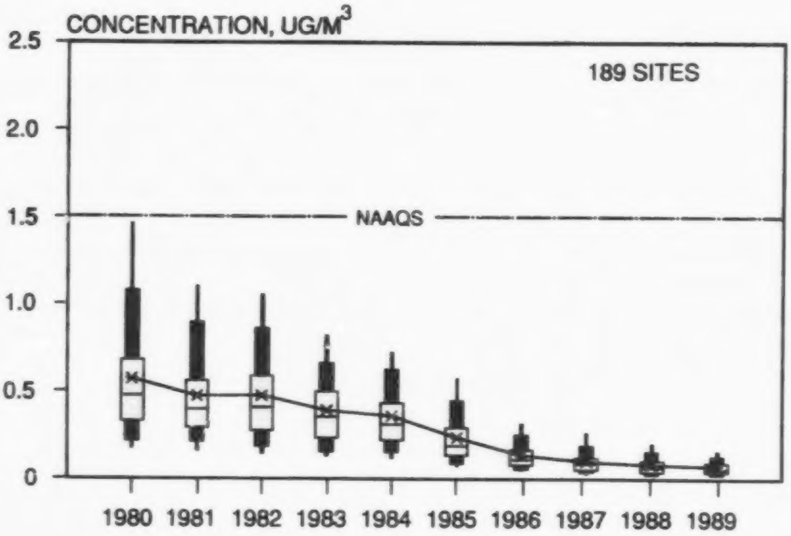


Figure 3-43. Boxplot comparisons of trends in maximum quarterly average lead concentrations at 189 sites, 1980-1989.

The results of these actions in 1989 amounted to a 66 percent reduction nationwide in total Pb emissions from 1985 levels. As noted reviously, unleaded gasoline represented 89 percent of 1989 total gasoline sales. Although the good agreement among the trend in lead consumption, emissions and ambient levels is based upon a limited geographical sample, it does show that ambient urban Pb levels are responding to the drop in lead emissions. In Canada a very similar trend in ambient lead concentrations has been observed. In a soon to be released report, declines in average lead concentrations of 86 percent were found for the 1980-89 time period.[24]

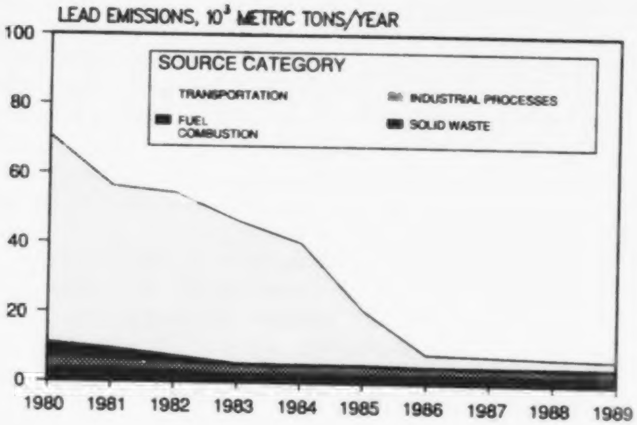


Figure 3-44. National trend in lead emissions, 1980-1989.

TABLE 3-8. NATIONAL LEAD EMISSION ESTIMATES, 1980-1989

(million metric tons/year)

SOURCE CATEGORY	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Transportation	59.4	46.9	46.9	40.8	34.7	15.5	3.5	3.0	2.6	2.2
Fuel Combustion	3.9	2.8	1.7	0.6	0.5	0.5	0.5	0.5	0.5	0.5
Industrial Processes	3.6	3.0	2.7	2.4	2.3	2.3	1.9	1.9	2.0	2.3
Solid Waste	3.7	3.7	3.1	2.6	2.6	2.6	2.6	2.6	2.5	2.3
Miscellaneous	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	70.6	56.4	54.4	46.4	40.1	20.9	8.4	8.0	7.6	7.2

NOTE: The sums of sub-categories may not equal total due to rounding.

3.6.2 Recent Pb Trends: 1987-89

Ambient Pb trends were also studied over the shorter period 1987-89. A total of 245 urban sites in 39 States met the data requirement that a site have all 3 years with data. In recent years, the number of lead sites has dropped because of the elimination of some TSP monitors from State and local air monitoring programs. Some monitors were eliminated due to the change in the particulate matter standard from TSP to PM_{10} while others were discontinued because of the very low lead concentrations measured in many urban locations. Although some further attrition may occur, the core network of NAMS lead sites together with supplementary State and local sites should be sufficient to access national ambient lead trends. This larger 3-year data base showed an improvement of 29 percent in average urban Pb concentrations. The 1987 and 1989 lead averages respectively were 0.099 and 0.070 ug/m3, a difference of only 0.029 ug/m3. This corresponds to reductions in total Pb emissions of 10 percent and a reduction of 27 percent in lead emissions from transportation sources. Most of this decrease in total nationwide Pb emissions was due once again to the decrease in automotive Pb emissions. Even this larger group of sites was disproportionately weighted by sites in California, Illinois, Kansas, Texas and West Virginia. These States had about 37 percent of the 245 sites represented. However, the percent changes in 1987-89 average Pb concentrations for these five States were very similar to the percent change for the remaining sites, thus the contributions of these sites did not distort the national trends. Although urban lead concentrations continue to decline consistently, there are indications that the rate of the decline has slowed down. Clearly in some areas, urban lead levels are so low, that further improvements have become difficult.

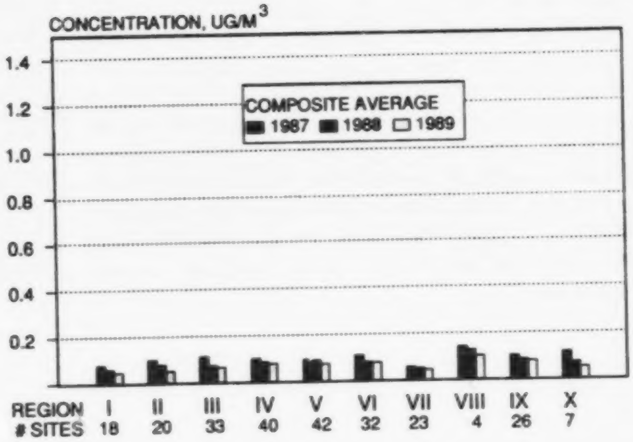


Figure 3-45. Regional comparison of the 1987,1988, 1989 composite average of the maximum quarterly average lead concentration.

Indeed, as will be shown later, all sections of the country are showing declines in average lead concentrations. Sixty-two (62) point source oriented sites showed an average drop of 37 percent over the 1987-89 time period. Thus, the decrease in ambient lead concentrations near lead point sources has been slightly more pronounced than in urban areas. The average lead levels at these sites are much higher here than at the urban sites. The 1987 and 1989 lead averages were 1.24 and 0.78 $\mu g/m^3$ respectively. It is worth noting that the sites in the 10-year data base also showed a 27 percent decrease during this 3-year period, suggesting that, despite the geographical imbalance, their patterns may adequately depict national trends.

The larger sample of sites represented in the 3-year trends (1987-89) will be used to compare the most recent individual yearly averages. However, for the 10 year time period the largest single year drop in average lead concentrations, 42 percent, occurs as expected between 1985 and 1986, because of the shift of the lead content in leaded gasoline. The 1989 average lead concentrations show the more modest decline of 14 percent from 1988 levels. The 10-year data base showed a 11 percent decrease in average lead concentrations from 1988 to 1989. Lead emissions between 1988 and 1989 decreased both for the total (5 percent) and from only transportation sources (15 percent). This trend is expected to continue primarily because the leaded gasoline market will continue to shrink. Some major petroleum companies have discontinued refining leaded gasoline because of the dwindling market, so that in the future the consumer will find it more difficult to purchase regular leaded gasoline.

Figure 3-45 shows 1987, 1988 and 1989 composite average Pb concentrations, by EPA Region. Once again the larger more representative 3-year data base of 245 sites was used for this comparison. The number of sites varies dramatically by Region from 4 in Region VIII to 42 in Region V. In all Regions, there is a decrease in average Pb urban concentrations between 1987 and 1989. These results confirm that average Pb concentrations in urban areas are continuing to decrease in all sections of the country, which is exactly what is to be expected because of the national air pollution control program in place for Pb.

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4. AIR QUALITY STATUS OF METROPOLITAN AREAS, 1989

This chapter provides general information on the current air quality status of metropolitan areas[1] within the United States. Four different summaries are presented in the following sections. First, maps depicting the areas failing to meet the National Ambient Air Quality Standards (NAAQS) for ozone, carbon monoxide and particulate matter are presented. Next, an estimate is provided of the number of people living in counties which did not meet the NAAQS based on 1989 air quality data. Third, pollutant-specific maps are presented to provide the reader with a geographical view of how peak 1989 air quality levels varied throughout the 90 largest Metropolitan Statistical Areas (MSAs) in the continental United States. Finally, the peak pollutant-specific statistics are listed for each MSA with 1989 air quality monitoring data.

4.1 Areas Not Meeting Ozone, Carbon Monoxide and Particulate Matter NAAQS

On August 16, 1990 the U.S. Environmental Protection Agency listed[2] those metropolitan areas which failed to meet the ozone and carbon monoxide NAAQS based on ambient monitoring data for 1987 through 1989. The areas include Consolidated Metropolitan Statistical Areas (CMSA), which are composed of groups of MSAs, and individual MSAs and non-metropolitan counties.

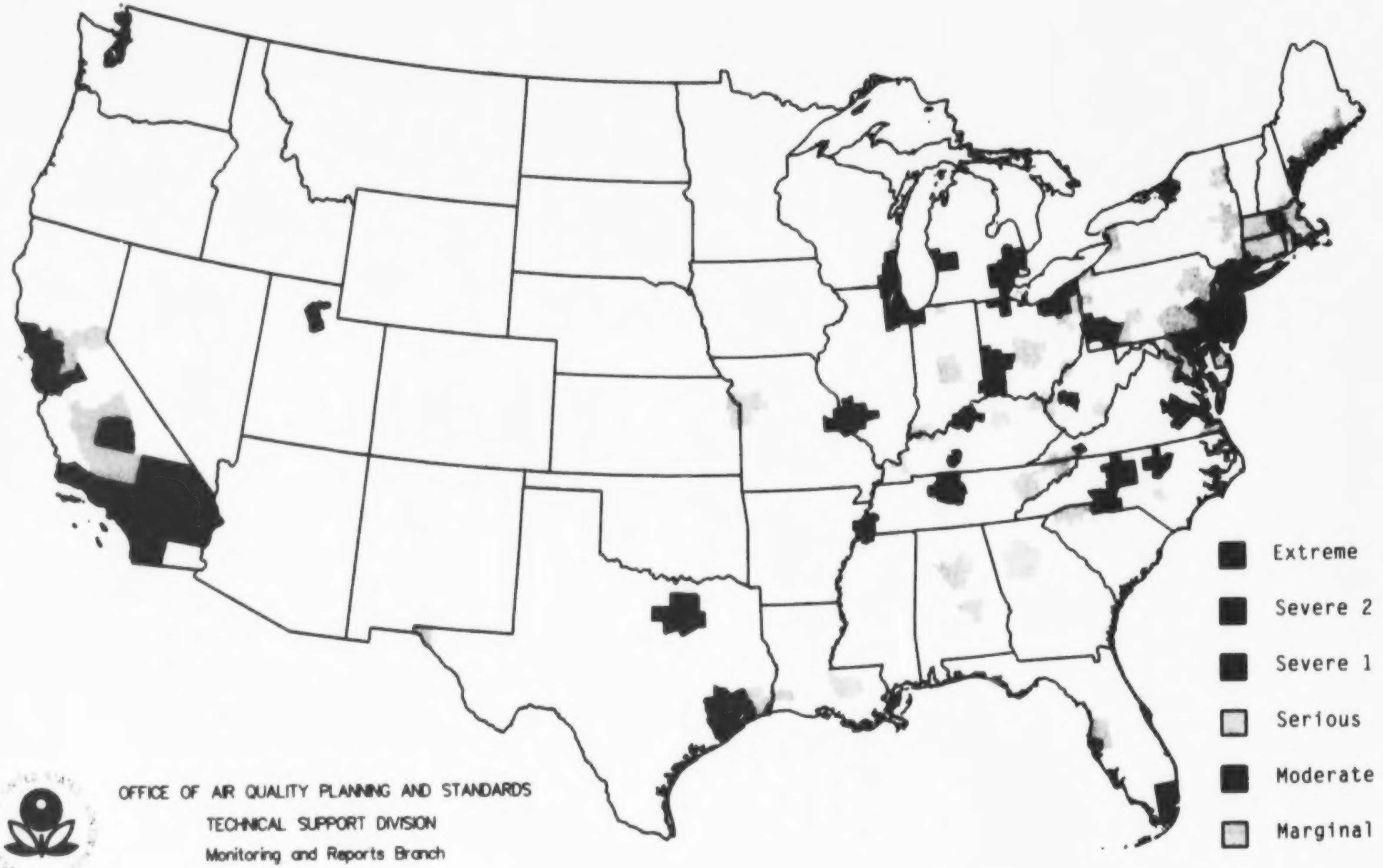
Attainment of the ozone standard is determined using the three most recent years of air quality monitoring data. These data showed that 96 areas, mostly major metropolitan areas, failed to meet the ozone standard for the years 1987-89, a decrease of 5 areas as compared to the 1986-88 period. Figure 4-1, "Areas Failing to Meet the Ozone NAAQS Based on 1987-89 Data," displays the 96 areas failing to meet the ozone standard based on 1987-89 monitoring data. The areas on the map are shaded according to the area classifications in the Clean Air Act Amendments of 1990. These area classes are based on the ozone design value for that area. The ozone design value serves as an indicator of the magnitude of the problem in terms of peak concentrations. Typically, the ozone design value would be the fourth highest daily maximum value during the three year period.

For carbon monoxide, attainment of the standard is determined using the two most recent years of monitoring data. The area classifications are based on the CO design value which is evaluated by computing the second maximum 8-hour concentration for each year and then using the higher of these two values. Figure 4-2, "Areas Failing to Meet the Carbon Monoxide NAAQS Based on 1988-89 Data," shows the 41 areas that failed to meet the carbon monoxide standard for the years 1988-89. Seven areas from last year's list now meet the carbon monoxide NAAQS, while four new areas failed to meet the standard in 1989.

With passage of the 1990 Amendments to the Clean Air Act, 73 areas failed to meet the NAAQS for particulate matter. Sixty of these areas were previously classified as "Group I," meaning that the area had a high probability of not attaining the NAAQS and that State Implementation Plans were required to attain the NAAQS. An additional 13 areas with measured violations of the PM_{10} NAAQS through calendar year 1988 have been identified, as specified by the act. Figure 4-3 displays the counties within the contiguous U.S. that contain these 73 areas. The map displays counties which are completely non-attainment or counties only parts of which are non-attainment. A total of 81 separate counties are involved for PM_{10}.

AREAS NOT MEETING THE OZONE NAAQS

Based on 1987-89 Data


■ Extreme
■ Severe 2
■ Severe 1
▨ Serious
■ Moderate
▨ Marginal

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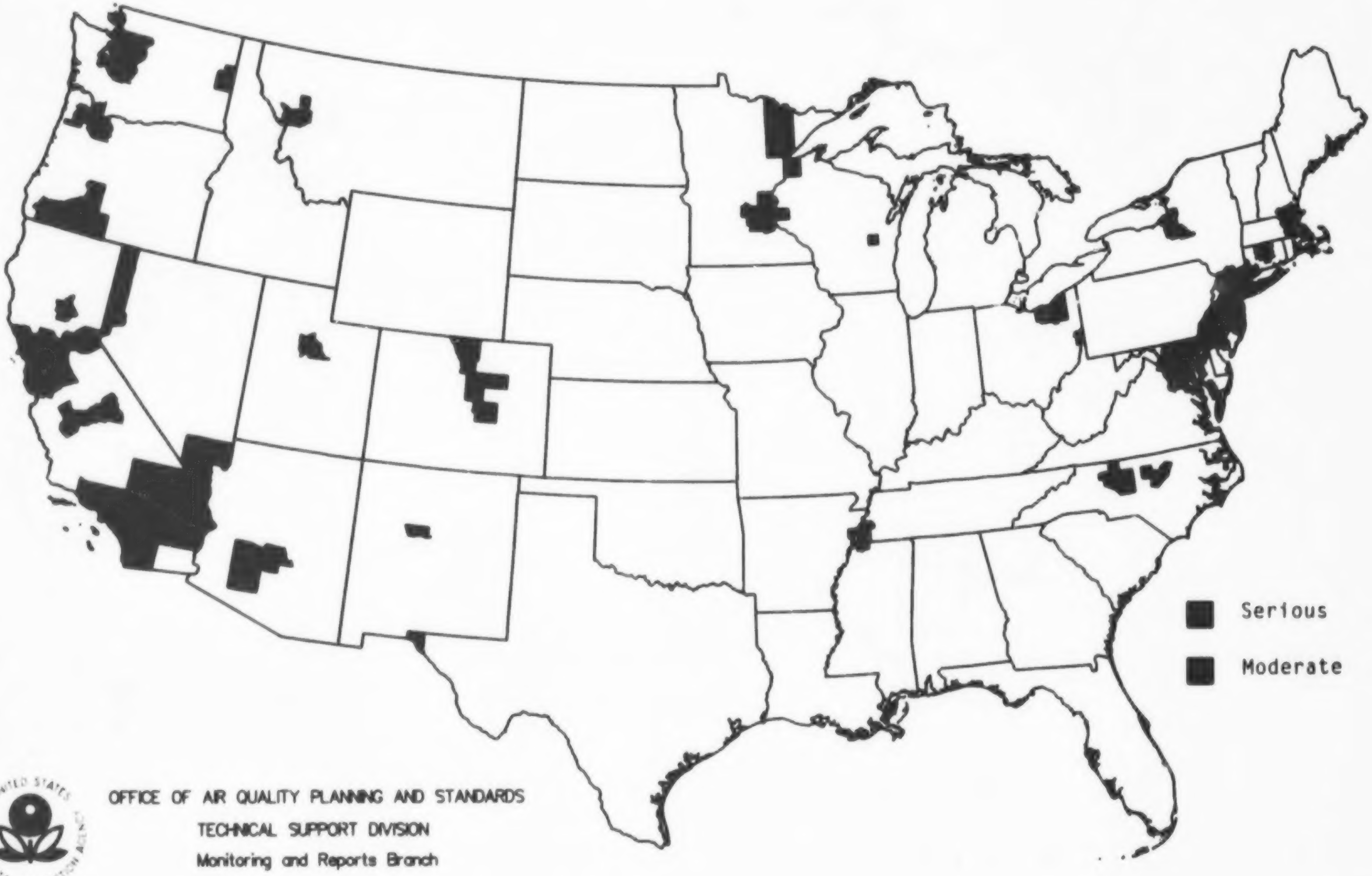
AREAS NOT MEETING THE CARBON MONOXIDE NAAQS

Based on 1988-89 Data



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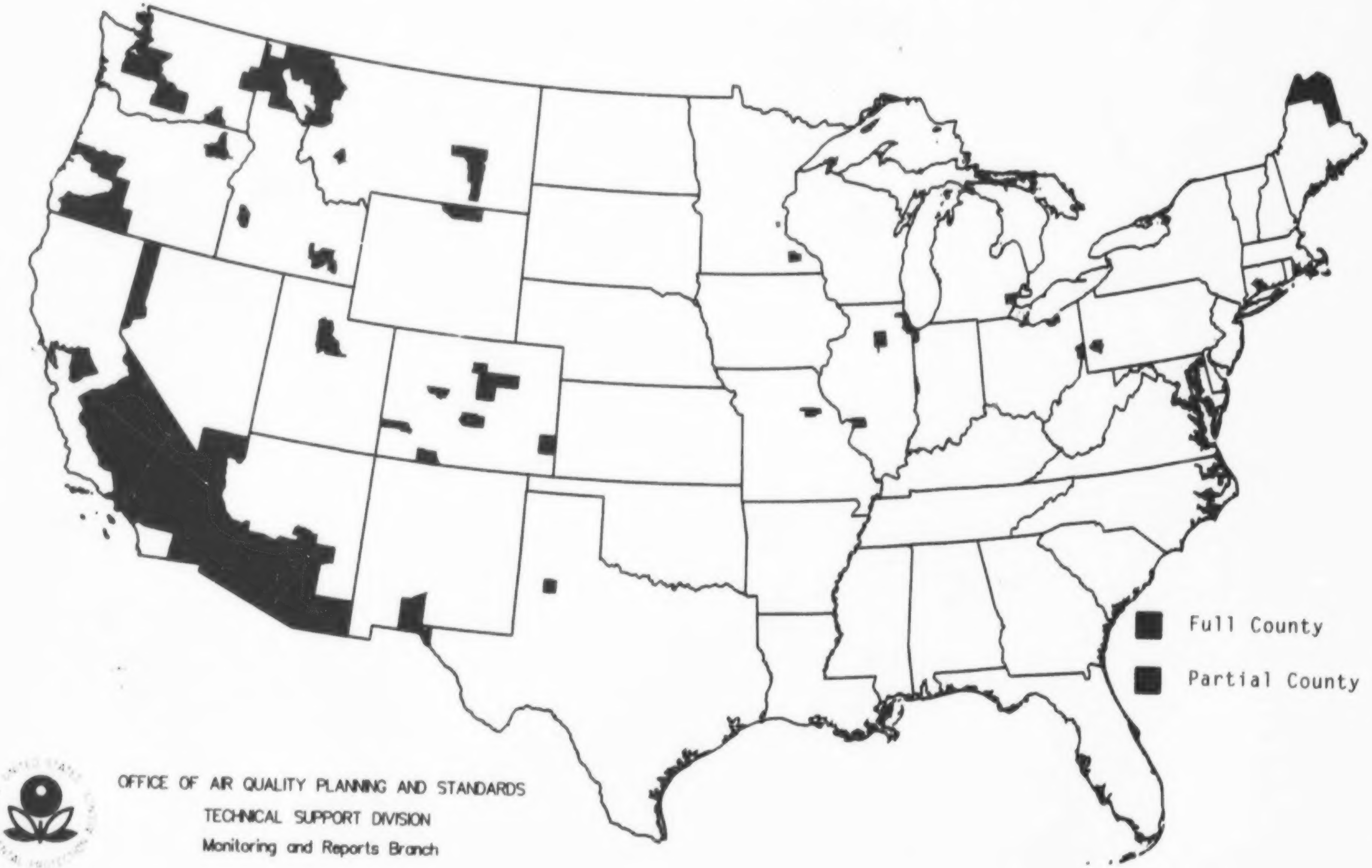
AREAS NOT MEETING THE PARTICULATE MATTER NAAQS

Based on Data through 1988


■ Full County
■ Partial County

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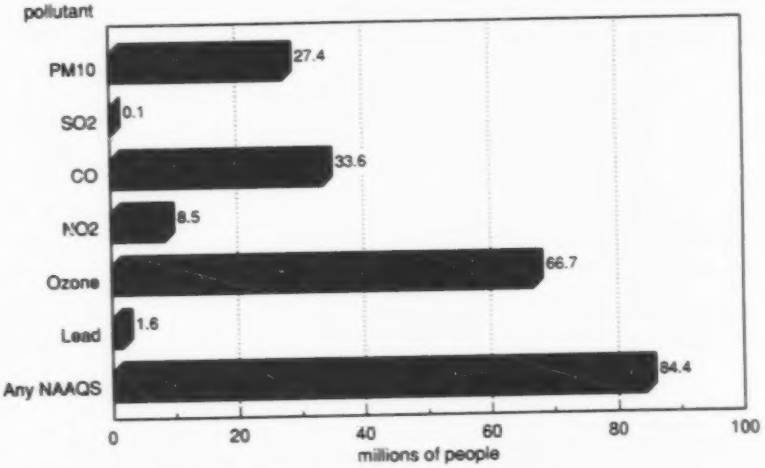
4.2 Population Estimates For Counties Not Meeting NAAQS, 1989

Figure 4-4 provides an estimate of the number of people living in counties in which the levels of the pollutant-specific primary health NAAQS were not met by measured air quality in 1989. These estimates use a single-year interpretation of the NAAQS to indicate the current extent of the problem for each pollutant. Table 4-1 lists the selected air quality statistics and their associated NAAQS. Figure 4-4 clearly demonstrates that O_3 was the most pervasive air pollution problem in 1989 for the United States with an estimated 66.7 million people living in counties which did not meet the O_3 standard. However, this estimate is substantially lower than last year's 1988 estimate of 112 million people. This large decrease is likely due in part to meteorological conditions in 1989 being less conducive to ozone formation than 1988 (recall the hot, dry summer in the eastern U.S.), and to new and ongoing emission control programs. Between 1988 and 1989, implementation of gasoline volatility regulations lowered the average Reid Vapor Pressure (RVP) of regular unleaded gasoline from 10.0 to 8.9 pounds per square inch (psi). Carbon monoxide follows, with 33.6 million people; PM_{10} with 27.4 million people; NO_2 with 8.5 million people; Pb with 1.6 million people and SO_2 with 0.9 million people. A total of 84 million persons resided in counties not meeting at least one air quality standard during 1989 (out of a total 1987 population of 243 million). In contrast to the last annual report which used 1986 county population data, these estimates are based on more current 1987 estimates. Thus, the 1 percent growth in total U.S. population since 1986 is reflected in these estimates. Also, the estimate for PM_{10} is considered a lower bound estimate, because the PM_{10} monitoring network is still evolving.

These population estimates are intended to provide a relative measure of the extent of the problem for each pollutant. The limitations of this indicator should be recognized. An individual living in a county that violates an air quality standard may not actually be exposed to unhealthy air. For example, if CO violations were confined to a traffic-congested center city location during evening rush hours in the winter, it is possible that an individual may never be in that area, or may be there only at other times of the day or during other seasons. However, it is worth noting that ozone, which appears to be the most pervasive pollution problem by this measure, is also the pollutant most likely to have fairly uniform concentrations throughout an area.



Note: Based on 1987 county population data and only 1989 air quality data.

Figure 4-4. Number of persons living in counties with air quality levels above the primary national ambient air quality standards in 1989 (based on 1987 population data).

Table 4-1. **Selected Air Quality Summary Statistics and Their Associated National Ambient Air Quality Standards (NAAQS)***

POLLUTANT	STATISTIC	PRIMARY NAAQS
Particulate Matter (PM_{10})	annual arithmetic mean	50 µg/m^3
Sulfur Dioxide (SO_2)	annual arithmetic mean	0.03 ppm
	second highest 24-hour average	0.14 ppm
Carbon Monoxide (CO)	second highest nonoverlapping 8-hour average	9 ppm
Nitrogen Dioxide (NO_2)	annual arithmetic mean	0.053 ppm
Ozone (O_3)	second highest daily maximum 1-hour average	0.12 ppm
Lead (Pb)	maximum quarterly average	1.5 µg/m^3

µg/m^3 = micrograms per cubic meter

ppm = parts per million

*Single year interpretation. For a detailed listing of the NAAQS see Table 2-1.

4.3 Air Quality Levels in Metropolitan Statistical Areas

This section provides information for general air pollution audiences on 1989 air quality levels in each Metropolitan Statistical Area (MSA) in the United States. For those large MSAs with populations greater than 500,000, the 1989 annual air quality statistics are also displayed geographically on three-dimensional maps.

The general concept of a metropolitan area is one of a large population center, with adjacent communities which have a high degree of economic and social integration with the urban center. Metropolitan Statistical Areas contain a central county(ies), and any adjacent counties with at least 50 percent of their population in the urbanized area.[1] Although MSAs compose only 16 percent of the land area in the U.S., they account for 77 percent of the population. Table 4-2 displays the population distribution of the 340 MSAs, based on 1987 population estimates.[1] The New York, NY MSA is the nation's largest metropolitan area with a 1987 population in excess of 8 million. The smallest MSA is Enid, OK with a population of 60,000.

4.3.1 Metropolitan Statistical Area Air Quality Maps, 1989

Figures 4-4 through 4-10 introduce air quality maps of the United States that show at a glance how air quality varies among the largest MSAs within the contiguous United States. To enable the reader to distinguish individual urban areas, only the 90 MSAs within the continental U.S. having populations greater than 500,000 are shown. Two large MSAs, Honolulu, HI and San Juan, PR are not shown. However, neither area has exceeded any of the NAAQS during 1989. In each map, a spike is plotted at the city location on the map surface. This represents the highest pollutant concentration recorded in 1989, corresponding to the appropriate air quality standard. Each spike is projected onto a back-drop for comparison with the level of the standard. The backdrop also provides an east-west profile of concentration variability throughout the country.

TABLE 4-2. Population Distribution of Metropolitan Statistical Areas Based on 1987 Population Estimates

POPULATION RANGE	NUMBER OF MSA'S	TOTAL POPULATION
≤ 100,000	27	2,274,000
100,000 < population ≤ 250,000	148	23,513,000
250,000 < population ≤ 500,000	73	25,218,000
500,000 < population ≤ 1,000,000	48	34,367,000
1,000,000 < population ≤ 2,000,000	26	38,685,000
population > 2,000,000	18	65,747,000
TOTAL	340	189,804,000

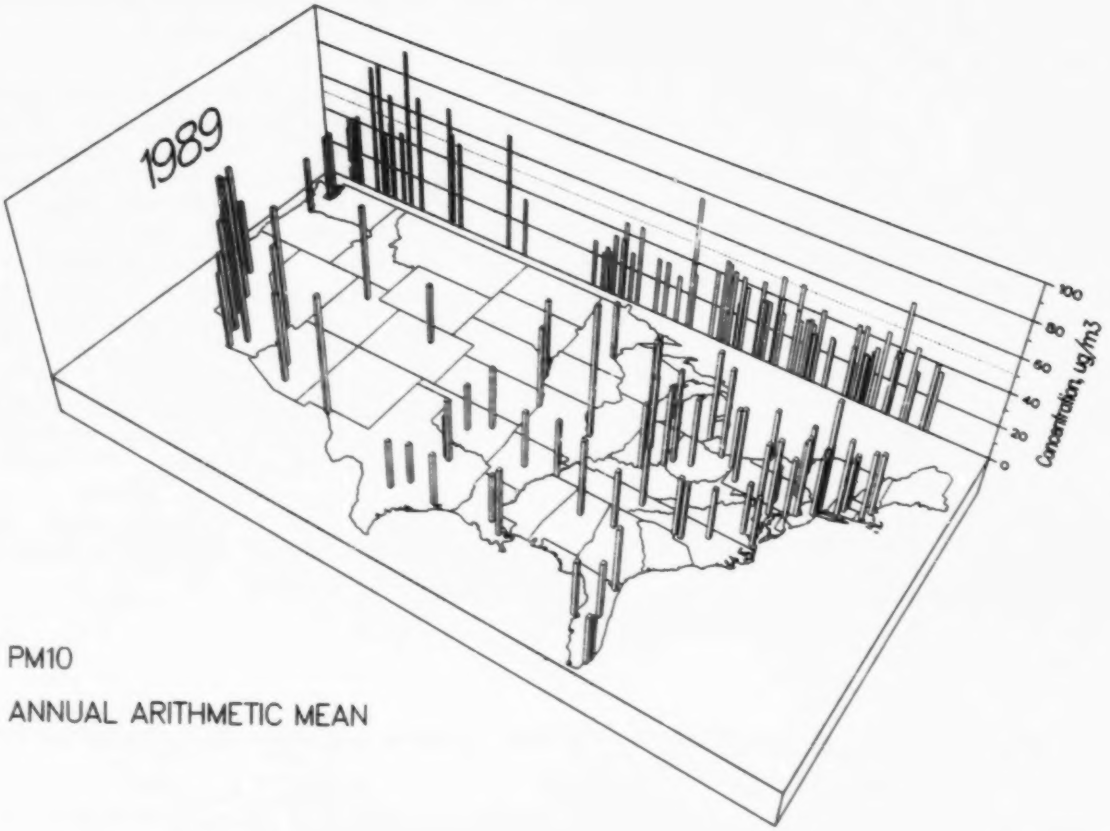

1989
PM10
ANNUAL ARITHMETIC MEAN
100
80
60
40
20
0
Concentration, ug/m3

Figure 4-5. United States map of the highest annual arithmetic mean PM_{10} concentration by MSA, 1989.

The map for PM_{10} shows the 1989 maximum annual arithmetic means in metropolitan areas greater than 500,000 population. Concentrations above the level of the annual mean PM_{10} standard of 50 ug/m^3 are found in 13 of these metropolitan areas.

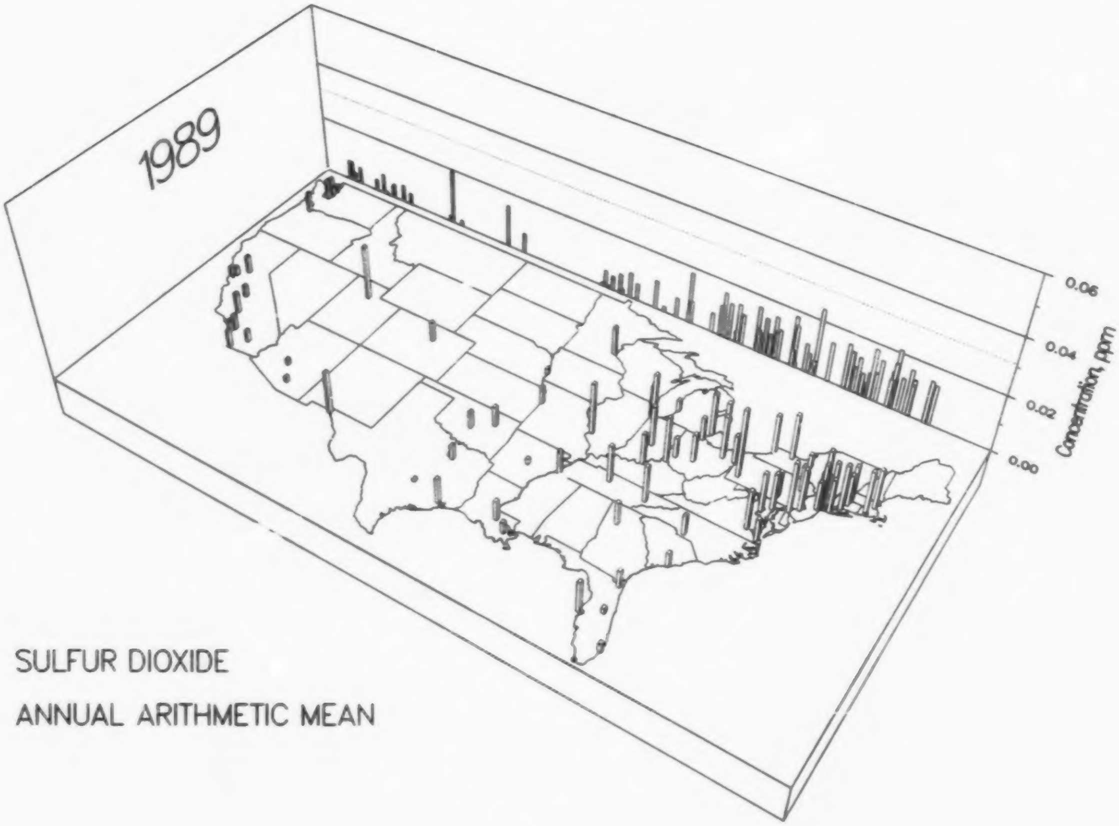


Figure 4-6. United States map of the highest annual arithmetic mean sulfur dioxide concentration by MSA, 1989.

The map for sulfur dioxide shows maximum annual mean concentrations in 1989. Among these large metropolitan areas, the higher concentrations are found in the heavily populated Midwest and Northeast and near point sources in the west. All these large urban areas have ambient air quality concentrations lower than the current annual standard of 80 ug/m^3 (0.03 ppm). Because this map only represents areas with population greater than one half million, it does not reflect air quality in the vicinity of smelters or large power plants in rural areas.

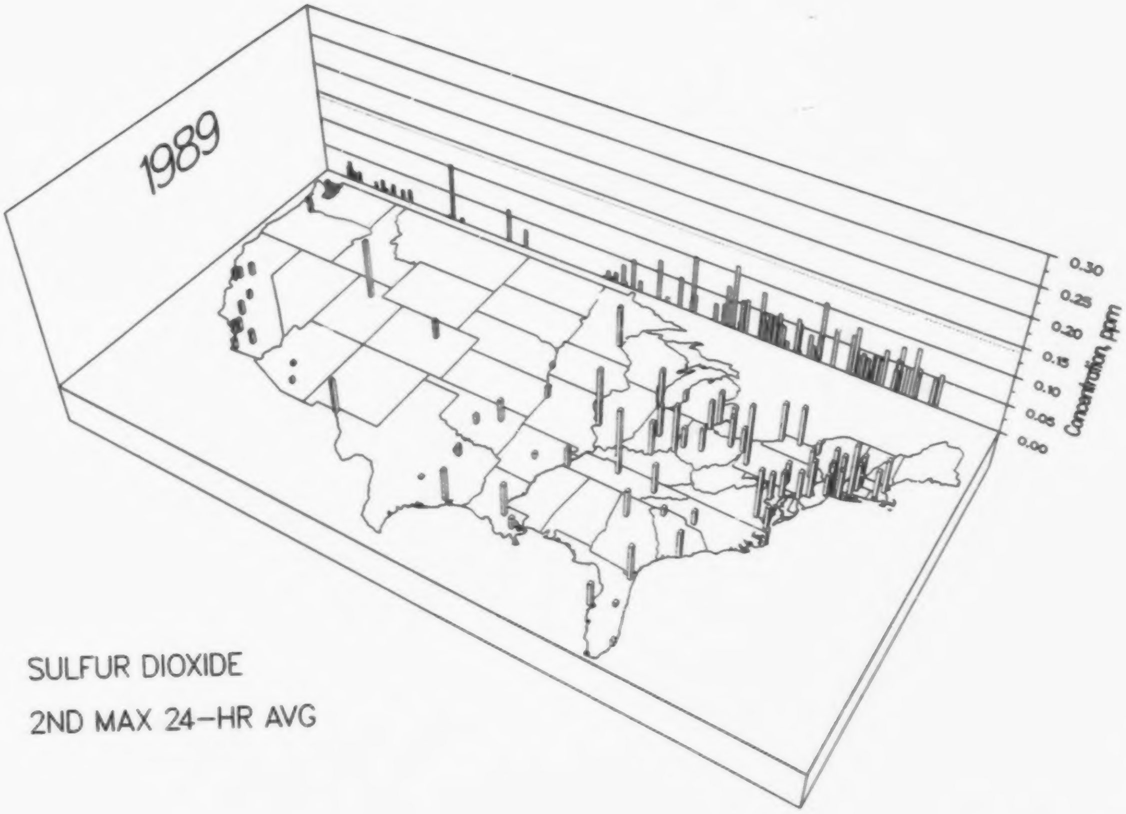

1989
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Concentration, ppm
SULFUR DIOXIDE
2ND MAX 24–HR AVG

Figure 4-7. **United States map of the highest second maximum 24-hour average sulfur dioxide concentration by MSA, 1989.**

The map for sulfur dioxide shows the highest second highest 24-hour average sulfur dioxide concentration by MSA in 1989. All of these large urban areas have ambient concentrations below the 24-hour NAAQS of 365 ug/m^3 (0.14 ppm).

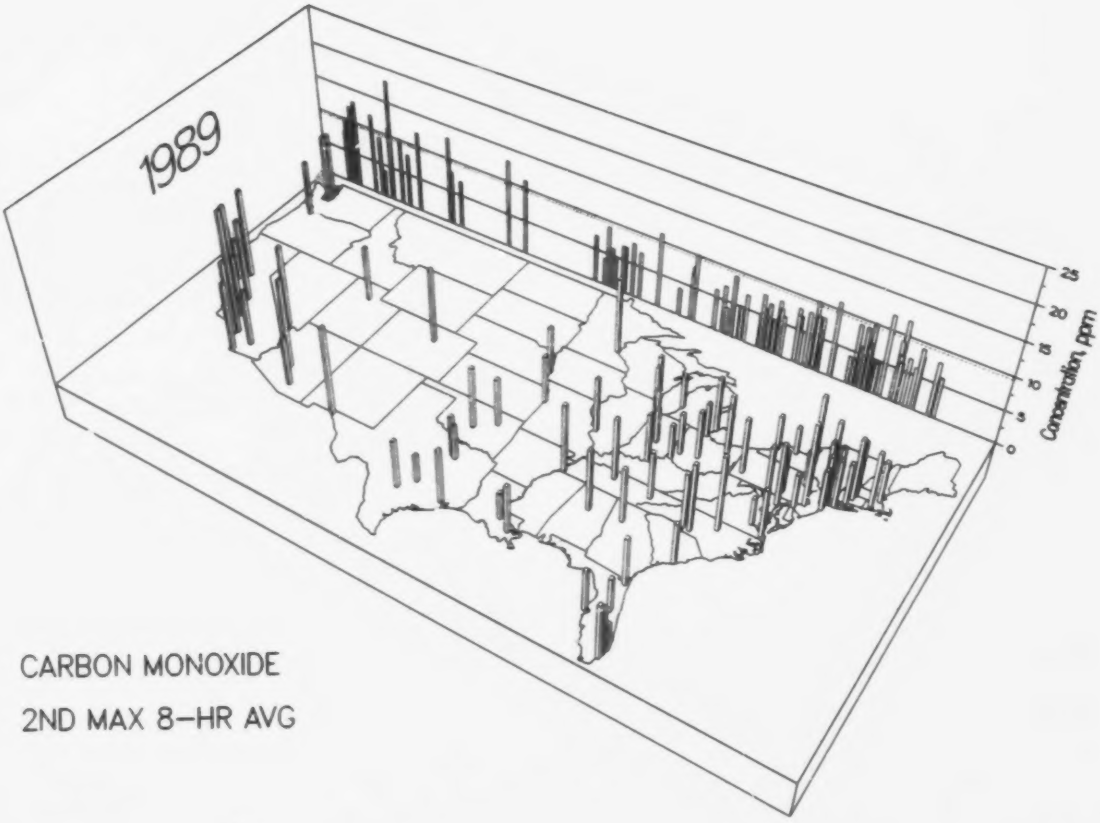

1989
CARBON MONOXIDE
2ND MAX 8–HR AVG
Concentration, ppm
0
5
10
15
20
25

Figure 4-8. United States map of the highest second maximum nonoverlapping 8-hour average carbon monoxide concentration by MSA, 1989.

The map for carbon monoxide shows the highest second highest 8-hour value recorded in 1989. Twenty of these urban areas in all geographic regions have air quality exceeding the 9 ppm level of the standard. The highest concentration recorded in 1989 is found in Los Angeles, CA.

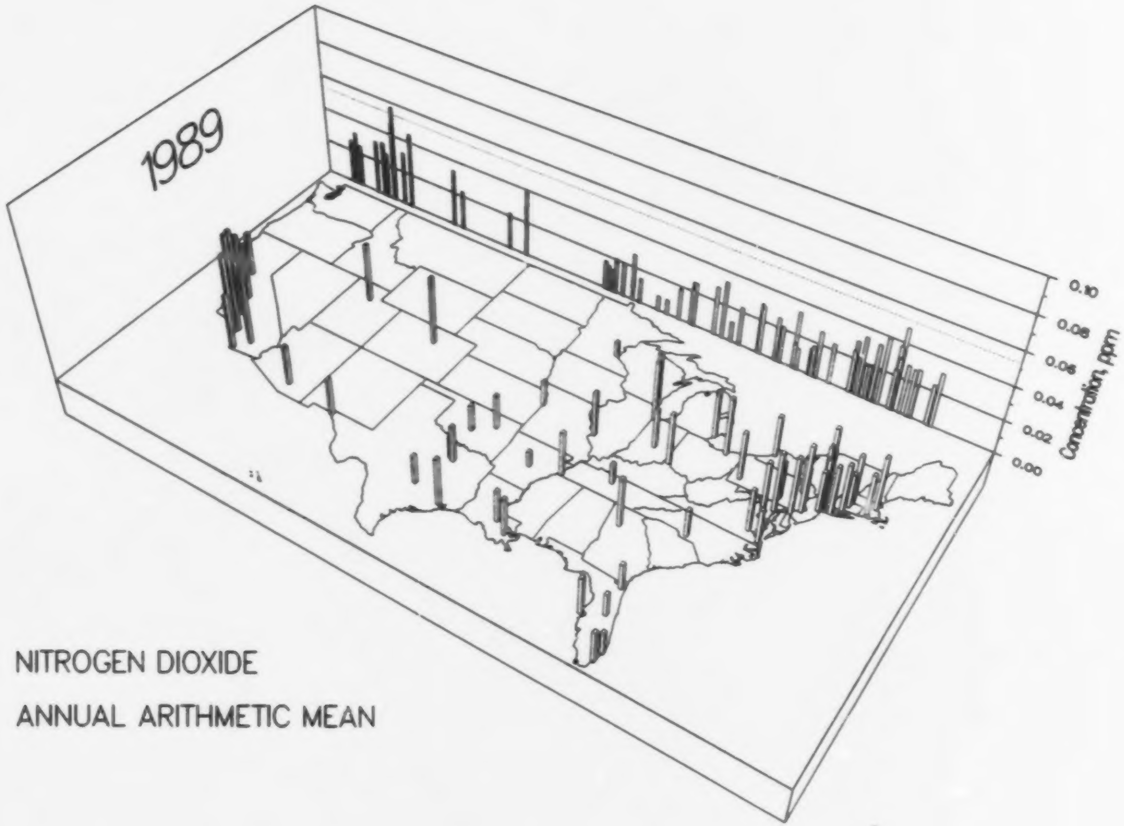


Figure 4-9. United States map of the highest annual arithmetic mean nitrogen dioxide concentration by MSA, 1989.

The map for nitrogen dioxide displays the maximum annual mean measured in the nation's largest metropolitan areas during 1989. Los Angeles, California, with an annual NO_2 mean of 0.057 ppm is the only area in the country exceeding the NO_2 air quality standard of 0.053 ppm.

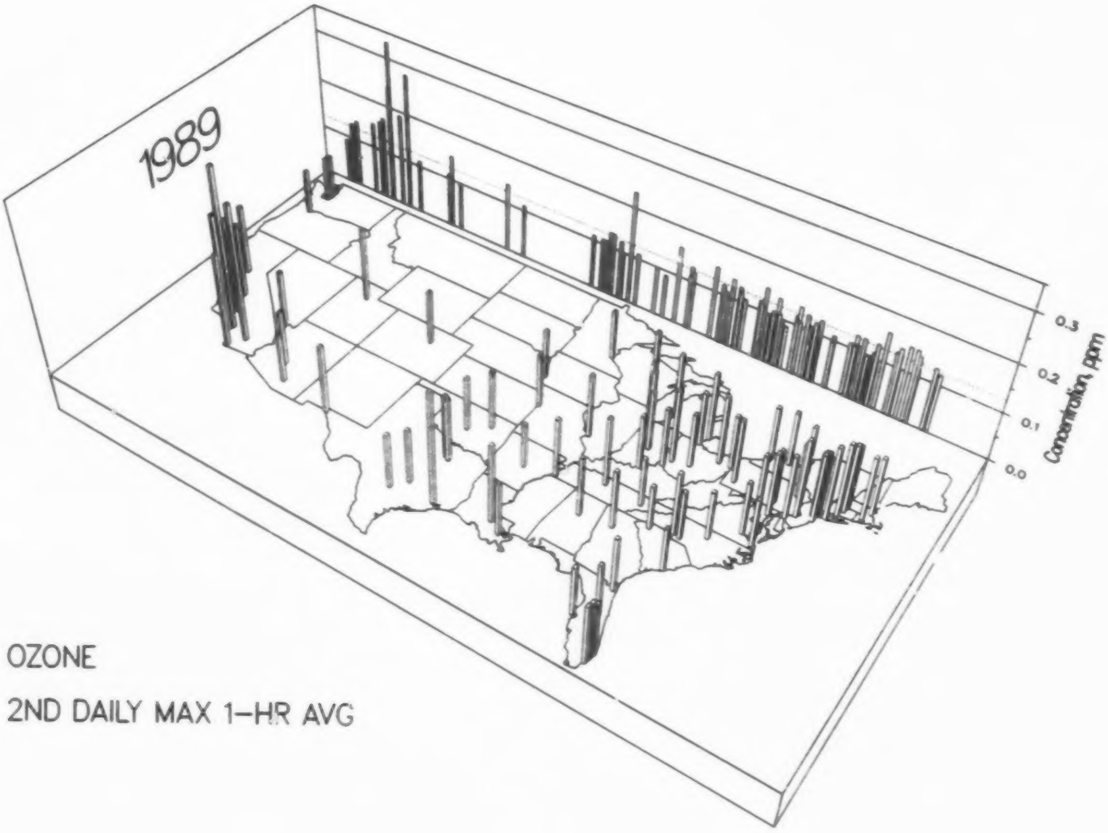

1989
OZONE
2ND DAILY MAX 1-HR AVG
0.3
0.2
0.1
0.0
Concentration, ppm

Figure 4-10. United States map of the highest second daily maximum 1-hour average ozone concentration by MSA, 1989.

The ozone map shows the second highest daily maximum 1-hour concentration in the 90 largest metropolitan areas in the Continental U.S. As shown, 38 of these areas did not meet the 0.12 ppm standard in 1989. The highest concentrations are observed in Southern California, but high levels also persist in the Texas Gulf Coast, Northeast Corridor, and other heavily populated regions.

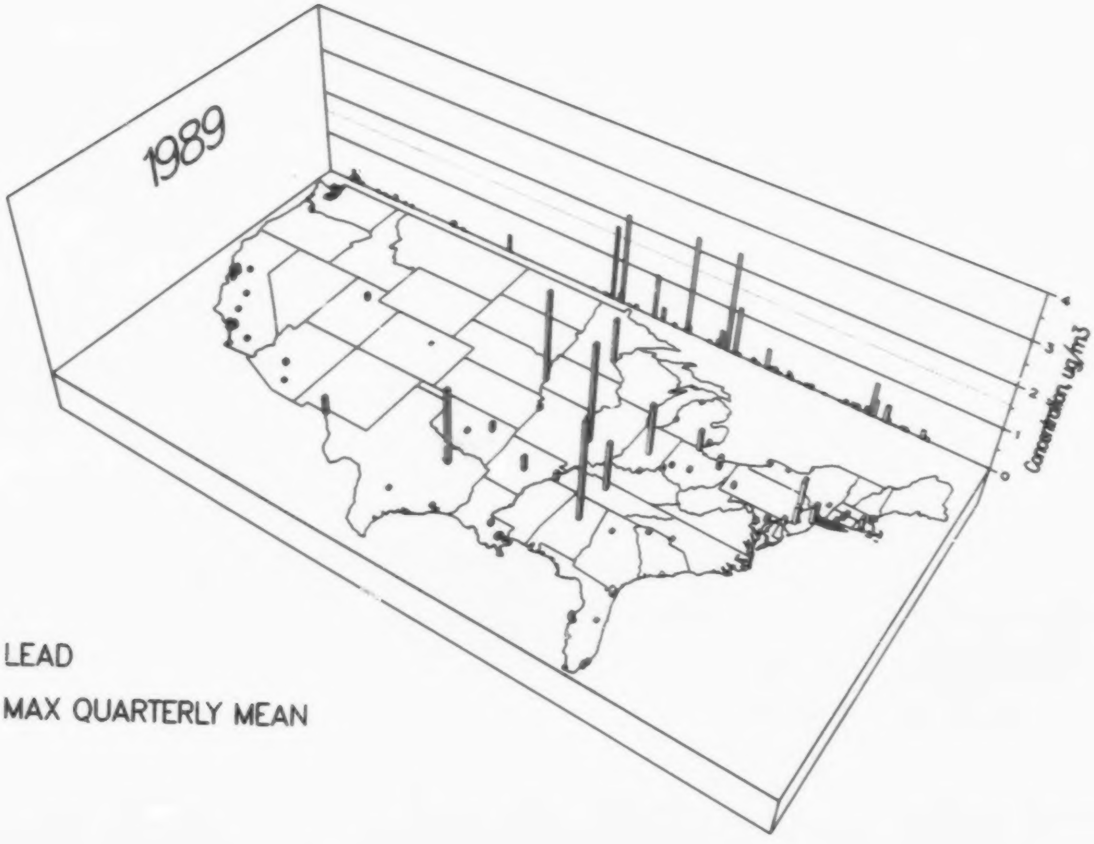


Figure 4-11. United States map of the highest maximum quarterly average lead concentration by MSA, 1989.

The map for Pb displays maximum quarterly average concentrations in the nation's largest metropolitan areas. Exceedances of the Pb NAAQS are found in four areas in the vicinity of nonferrous smelters or other point sources of lead. The two highest concentrations are found at a site near a primary lead smelter in Herculaneum, MO (St. Louis MSA) and at a site in Leeds, AL (Birmingham MSA). Because of the switch to unleaded gasoline, areas primarily affected by automotive lead emissions show levels below the current standard of 1.5 ug/m^3.

4.3.2 Metropolitan Statistical Area Air Quality Summary, 1989

Table 4-3 presents a summary of 1989 air quality for each Metropolitan Statistical Area (MSA) in the United States. The air quality levels reported for each metropolitan area are the highest levels measured from all available sites within the MSA. The MSAs are listed alphabetically, with the 1987 population estimate and air quality statistics for each pollutant. Concentrations above the level of the respective NAAQS are shown in **bold** type.

In the case of O_3, the problem is pervasive, and the high values associated with the pollutant can reflect a large part of the MSA. However in many cases, peak ozone concentrations occur downwind of major urban areas, e.g., peak ozone levels attributed to the Chicago metropolitan area are recorded in and near Racine, Wisconsin. In contrast, high CO values generally are highly localized and reflect areas with heavy traffic. The scale of measurement for the pollutants - PM_{10}, SO_2 and NO_2 - falls somewhere in between. Finally, while Pb measurements generally reflect Pb concentrations near roadways in the MSA, if a monitor is located near a point source of lead emissions it can produce readings substantially higher. Such is the case in several MSAs. Pb monitors located near a point source are footnoted accordingly in Table 4-3.

The pollutant-specific statistics reported in this Section are summarized in Table 4-1, with their associated primary NAAQS concentrations for a single year of data. For example, if an MSA has three ozone monitors in 1989 with second highest daily hourly maxima of 0.15 ppm, 0.14 ppm and 0.12 ppm, the highest of these, 0.15 ppm, would be reported for that MSA for 1989.

The same annual data completeness criteria used in the air quality trends data base for continuous data was used here for the calculation of annual means. (i.e., 50 percent of the required samples for SO_2 and NO_2). If some data have been collected at one or more sites, but none of these sites meet the annual data completeness criteria, then the reader will be advised that there are insufficient data to calculate the annual mean. With respect to the summary statistics on air quality levels with averaging times less than or equal to 24-hours, all sites are included, even if they do not meet the annual data completeness requirement.

For PM_{10} and Pb, the arithmetic mean statistics are based on 24-hour measurements, which are typically obtained from a systematic sampling schedule. In contrast to the trends analyses in Section 3 which used a more relaxed indicator, only maximum quarterly average Pb concentrations and weighted PM_{10} annual means meeting the AIRS validity criteria are displayed in Table 4-3.

This summary provides the reader with information on how air quality varied among the nation's metropolitan areas in 1989. The highest air quality levels measured in each MSA are summarized for each pollutant monitored in 1989. Individual MSAs are listed to provide more extensive spatial coverage for large metropolitan complexes.

The reader is cautioned that this summary is not adequate in itself to numerically rank MSAs according to their air quality. To rank properly the air pollution severity among different MSAs, data on population characteristics, daily population mobility, transportation patterns, industrial composition, emission inventories, meteorological factors and, most important, the spatial representativeness of the monitoring sites would also be needed.

4.4 REFERENCES

1. Statistical Abstract of the United States, 1989, U. S. Department of Commerce, U. S. Bureau of the Census, Appendix II.

2. "EPA Lists Places Failing To Meet Ozone or Carbon Monoxide Standards", Press Release, U.S. Environmental Protection Agency, Washington, D.C., August 16, 1990.

TABLE 4-3. 1989 METROPOLITAN STATISTICAL AREA (MSA) AIR QUALITY FACTBOOK
PEAK STATISTICS FOR SELECTED POLLUTANTS BY MSA

METROPOLITAN STATISTICAL AREA	1987 POPULATION	PM10 AM (UGM)	SO2 AM (PPM)	SO2 24-HR (PPM)	CO 8HR (PPM)	NO2 AM (PPM)	OZONE 2ND DMX (PPM)	PB QMAX (UGM)
ABILENE, TX	123,000	ND	ND	ND	ND	ND	ND	ND
AGUADILLA, PR	156,000	ND	ND	ND	ND	ND	ND	ND
AKRON, OH	647,000	IN	0.015	0.054	7	ND	**0.14**	0.10
ALBANY, GA	117,000	ND	0.003	0.016	ND	ND	ND	ND
ALBANY-SCHENECTADY-TROY, NY	846,000	IN	0.011	0.040	6	ND	0.10	0.03
ALBUQUERQUE, NM	486,000	37	ND	ND	**11**	0.019	0.10	0.05
ALEXANDRIA, LA	140,000	ND	ND	ND	ND	ND	ND	ND
ALLENTOWN-BETHLEHEM, PA-NJ	666,000	IN	0.010	0.047	5	0.020	0.10	0.78
ALTOONA, PA	132,000	25	0.011	0.059	ND	ND	0.10	ND
AMARILLO, TX	197,000	ND	ND	ND	ND	ND	ND	ND
ANAHEIM-SANTA ANA, CA	2,219,000	47	0.004	0.013	**11**	0.047	**0.24**	0.08
ANCHORAGE, AK	223,000	31	ND	ND	**13**	ND	ND	ND
ANDERSON, IN	133,000	IN	ND	ND	ND	ND	0.10	ND
ANDERSON, SC	141,000	ND	ND	ND	ND	ND	ND	0.02
ANN ARBOR, MI	268,000	ND	ND	ND	ND	ND	0.10	0.02
ANNISTON, AL	122,000	ND	ND	ND	ND	ND	ND	ND
APPLETON-OSHKOSH-NEENAH, WI	309,000	ND	ND	ND	**16**	ND	0.10	ND
ARECIBO, PR	170,000	ND	ND	ND	ND	ND	ND	ND
ASHEVILLE, NC	171,000	29	ND	ND	ND	ND	0.08	ND
ATHENS, GA	142,000	ND	ND	ND	ND	ND	ND	ND
ATLANTA, GA	2,657,000	34	0.008	0.046	8	0.029	0.12	0.04
ATLANTIC CITY, NJ	303,000	IN	0.005	0.029	ND	ND	0.12	0.07
AUGUSTA, GA-SC	392,000	IN	ND	ND	ND	ND	0.10	0.03
AURORA-ELGIN, IL	352,000	ND	ND	ND	ND	ND	0.11	ND
AUSTIN, TX	738,000	23	0.001	0.004	4	0.017	0.11	ND
BAKERSFIELD, CA	505,000	**79**	0.007	0.022	9	0.033	**0.16**	0.06
BALTIMORE, MD	2,303,000	44	0.013	0.044	9	0.035	**0.13**	0.11
BANGOR, ME	84,000	27	ND	ND	ND	ND	ND	0.04
BATON ROUGE, LA	538,000	28	0.007	0.056	4	0.019	**0.16**	0.09
BATTLE CREEK, MI	138,000	IN	ND	ND	ND	ND	ND	ND
BEAUMONT-PORT ARTHUR, TX	371,000	IN	0.008	0.124	2	0.007	**0.15**	0.02
BEAVER COUNTY, PA	191,000	34	0.023	0.128	4	0.020	0.10	0.27
BELLINGHAM, WA	115,000	IN	0.006	0.018	7	ND	0.05	ND
BENTON HARBOR, MI	165,000	ND	ND	ND	ND	ND	ND	ND
BERGEN-PASSAIC, NJ	1,294,000	40	0.012	0.045	8	0.035	0.12	0.05
BILLINGS, MT	118,000	IN	0.022	0.121	6	ND	0.08	ND
BILOXI-GULFPORT, MS	206,000	ND	0.006	0.029	ND	ND	ND	ND
BINGHAMTON, NY	260,000	ND	ND	ND	ND	ND	ND	ND
BIRMINGHAM, AL	917,000	44	ND	ND	9	ND	0.12	**2.32**•
BISMARK, ND	86,000	21	ND	ND	ND	ND	ND	ND

BLOOMINGTON, IN	104,000	ND	ND	ND	ND	ND	ND	ND
BLOOMINGTON-NORMAL, IL	124,000	ND	ND	ND	ND	ND	ND	ND
BOISE CITY, ID	196,000	IN	ND	ND	5	ND	ND	0.06
BOSTON, MA	2,842,000	36	0.014	0.058	6	0.032	0.12	0.08
BOULDER-LONGMONT, CO	217,000	IN	ND	ND	7	ND	0.11	ND
BRADENTON, FL	184,000	ND	ND	ND	ND	ND	0.10	ND
BRAZORIA, TX	187,000	ND	ND	ND	ND	ND	ND	ND
BREMERTON, WA	174,000	ND	ND	ND	6	ND	ND	ND
BRIDGEPORT-MILFORD, CT	444,000	36	0.014	0.051	5	0.026	**0.18**	0.07
BRISTOL, CT	78,000	23	ND	ND	ND	ND	ND	ND
BROCKTON, MA	185,000	ND	ND	ND	ND	ND	**0.13**	ND
BROWNSVILLE-HARLINGEN, TX	264,000	IN	ND	ND	ND	ND	ND	ND
BRYAN-COLLEGE STATION, TX	118,000	ND	ND	ND	ND	ND	ND	ND
BUFFALO, NY	958,000	29	0.014	0.068	5	0.024	0.11	0.04
BURLINGTON, NC	105,000	ND	ND	ND	ND	ND	ND	ND
BURLINGTON, VT	127,000	IN	0.007	0.031	4	0.019	ND	0.02
CAGUAS, PR	275,000	ND	ND	ND	ND	ND	ND	ND
CANTON, OH	397,000	37	0.012	0.041	5	ND	0.12	ND
CASPER, WY	67,000	ND	ND	ND	ND	ND	ND	ND
CEDAR RAPIDS, IA	170,000	34	0.009	0.078	3	ND	0.08	ND
CHAMPAIGN-URBANA-RANTOUL, IL	173,000	IN	0.005	0.025	ND	ND	0.09	ND
CHARLESTON, SC	502,000	IN	0.005	0.045	6	ND	0.09	0.04
CHARLESTON, WV	261,000	35	0.015	0.076	3	0.021	0.10	0.04
CHARLOTTE-GASTONIA-ROCK HILL, NC-SC	1,091,000	34	ND	ND	8	IN	**0.13**	0.03
CHARLOTTESVILLE, VA	123,000	30	ND	ND	ND	ND	ND	ND
CHATTANOOGA, TN-GA	432,000	35	ND	ND	ND	ND	0.11	ND
CHEYENNE, WY	76,000	ND	ND	ND	ND	ND	ND	ND

PM10 = HIGHEST ARITHMETIC MEAN CONCENTRATION (Applicable NAAQS is 50 ug/m³)
SO2 = HIGHEST ARITHMETIC MEAN CONCENTRATION (Applicable NAAQS is 0.03 ppm)
HIGHEST SECOND MAXIMUM 24-HOUR CONCENTRATION (Applicable NAAQS is 0.14 ppm)
CO = HIGHEST SECOND MAXIMUM NONOVERLAPPING 8-HOUR CONCENTRATION (Applicable NAAQS is 9 ppm)
NO2 = HIGHEST ARITHMETIC MEAN CONCENTRATION (Applicable NAAQS is 0.053 ppm)
O3 = HIGHEST SECOND DAILY MAXIMUM 1-HOUR CONCENTRATION (Applicable NAAQS is 0.12 ppm)
PB = HIGHEST QUARTERLY MAXIMUM CONCENTRATION (Applicable NAAQS is 1.15 ug/m³)

ND = INDICATES DATA NOT AVAILABLE
IN = INDICATES INSUFFICIENT DATA TO CALCULATE SUMMARY STATISTIC

UGM = UNITS ARE MICROGRAMS PER CUBIC METER
PPM = UNITS ARE PARTS PER MILLION

* - Impact from an industrial source in Leeds, Al. Highest site in Birmingham, AL is 0.20 ug/m3.

TABLE 4-3. 1989 METROPOLITAN STATISTICAL AREA (MSA) AIR QUALITY FACTBOOK
PEAK STATISTICS FOR SELECTED POLLUTANTS BY MSA

METROPOLITAN STATISTICAL AREA	1987 POPULATION	PM10 AM (UGM)	SO2 AM (PPM)	SO2 24-HR (PPM)	CO 8HR (PPM)	NO2 AM (PPM)	OZONE 2ND DMX (PPM)	PB QMAX (UGM)
CHICAGO, IL	6,199,000	48	0.011	0.037	7	0.034	0.12	0.16
CHICO, CA	169,000	35	ND	ND	9	0.016	0.10	ND
CINCINNATI, OH-KY-IN	1,438,000	45	0.016	0.084	5	0.030	0.12	0.11
CLARKSVILLE-HOPKINSVILLE, TN-KY	157,000	IN	0.007	0.042	2	ND	ND	ND
CLEVELAND, OH	1,851,000	**52**	0.018	0.061	8	0.034	0.12	0.17
COLORADO SPRINGS, CO	390,000	34	ND	ND	8	ND	0.09	ND
COLUMBIA, MO	107,000	28	0.008	0.037	ND	ND	ND	ND
COLUMBIA, SC	451,000	IN	0.003	0.017	7	ND	0.10	0.04
COLUMBUS, GA-AL	246,000	IN	ND	ND	ND	ND	0.09	ND
COLUMBUS, OH	1,320,000	40	0.010	0.041	7	ND	0.11	0.08
CORPUS CHRISTI, TX	360,000	33	0.003	0.021	ND	ND	0.10	ND
CUMBERLAND, MD-WV	102,000	ND	0.011	0.049	4	ND	ND	ND
DALLAS, TX	2,456,000	36	0.005	0.018	5	0.021	**0.13**	**1.76•**
DANBURY, CT	189,000	25	0.008	0.035	ND	ND	**0.13**	ND
DANVILLE, VA	109,000	ND	ND	ND	ND	ND	ND	ND
DAVENPORT-ROCK ISLAND-MOLINE, IA-IL	367,000	29	0.006	0.031	4	ND	0.11	0.02
DAYTON-SPRINGFIELD, OH	939,000	35	0.007	0.035	6	ND	**0.15**	0.06
DAYTONA BEACH, FL	332,000	ND	IN	0.003	ND	ND	ND	ND
DECATUR, AL	131,000	IN	ND	ND	ND	ND	ND	ND
DECATUR, IL	125,000	40	0.012	0.108	ND	ND	0.09	0.07
DENVER, CO	1,645,000	35	0.007	0.033	**11**	0.040	0.11	0.02
DES MOINES, IA	385,000	37	ND	ND	5	ND	0.08	ND
DETROIT, MI	4,362,000	**52**	0.015	0.058	8	0.026	**0.14**	0.09
DOTHAN, AL	130,000	IN	ND	ND	ND	ND	ND	ND
DUBUQUE, IA	91,000	ND	0.005	0.030	ND	ND	ND	ND
DULUTH, MN-WI	242,000	25	0.005	0.086	**10**	ND	0.06	ND
EAU CLAIRE, WI	137,000	ND	ND	ND	ND	ND	ND	ND
EL PASO, TX	573,000	**69**	0.015	0.059	**13**	0.022	**0.14**	0.42
ELKHART-GOSHEN, IN	150,000	ND	ND	ND	ND	ND	ND	ND
ELMIRA, NY	90,000	ND	0.005	0.026	ND	ND	0.09	ND
ENID, OK	60,000	ND	ND	ND	ND	ND	ND	ND
ERIE, PA	279,000	IN	0.014	0.074	4	0.015	0.12	ND
EUGENE-SPRINGFIELD, OR	265,000	38	ND	ND	6	ND	0.08	0.02
EVANSVILLE, IN-KY	281,000	39	0.020	0.110	4	0.020	0.12	ND
FALL RIVER, MA-RI	153,000	22	0.009	0.063	ND	ND	ND	ND
FARGO-MOORHEAD, ND-MN	147,000	21	ND	ND	ND	ND	ND	ND
FAYETTEVILLE, NC	259,000	29	ND	ND	8	ND	0.11	ND
FAYETTEVILLE-SPRINGDALE, AR	110,000	IN	ND	ND	ND	ND	ND	ND
FITCHBURG-LEOMINSTER, MA	96,000	ND	ND	ND	ND	ND	ND	ND
FLINT, MI	435,000	26	0.004	0.026	ND	ND	0.10	0.02

FLORENCE, AL	136,000	ND	0.006	0.060	ND	ND	ND	ND
FLORENCE, SC	117,000	ND	ND	ND	ND	ND	ND	ND
FORT COLLINS, CO	180,000	IN	ND	ND	8	ND	0.09	ND
FORT LAUDERDALE-HOLLYWOOD-POMPANO BE	1,163,000	25	ND	ND	7	ND	0.12	0.05
FORT MYERS-CAPE CORAL, FL	295,000	ND	ND	ND	ND	ND	0.10	ND
FORT PIERCE, FL	215,000	ND	ND	ND	ND	ND	ND	ND
FORT SMITH, AR-OK	178,000	IN	ND	ND	ND	ND	ND	ND
FORT WALTON BEACH, FL	145,000	ND	ND	ND	ND	ND	ND	ND
FORT WAYNE, IN	364,000	29	0.005	0.026	6	0.011	0.12	ND
FORT WORTH-ARLINGTON, TX	1,269,000	25	0.001	0.007	6	0.013	**0.13**	0.04
FRESNO, CA	597,000	**76**	0.004	0.013	**12**	0.032	**0.15**	0.07
GADSDEN, AL	103,000	31	ND	ND	ND	ND	ND	ND
GAINESVILLE, FL	205,000	ND	IN	0.008	ND	ND	ND	ND
GALVESTON-TEXAS CITY, TX	211,000	IN	0.008	0.045	ND	ND	**0.14**	0.03
GARY-HAMMOND, IN	604,000	47	0.016	0.072	4	IN	0.11	0.42
GLENS FALLS, NY	112,000	ND	0.004	0.023	ND	ND	ND	ND
GRAND FORKS, ND	70,000	IN	ND	ND	ND	ND	ND	ND
GRAND RAPIDS, MI	657,000	27	0.004	0.016	5	IN	**0.13**	0.04
GREAT FALLS, MT	78,000	20	ND	ND	8	ND	ND	ND
GREELEY, CO	135,000	30	ND	ND	7	ND	0.10	ND
GREEN BAY, WI	188,000	IN	0.008	0.030	ND	ND	0.09	ND
GREENSBORO-WINSTON SALEM-HIGH POINT,	916,000	33	0.007	0.024	**10**	0.016	0.10	ND
GREENVILLE-SPARTANBURG, SC	612,000	IN	IN	0.014	ND	ND	0.10	0.05
HAGERSTOWN, MD	116,000	ND	ND	ND	ND	ND	ND	ND
HAMILTON-MIDDLETOWN, OH	276,000	IN	0.011	0.046	ND	ND	0.11	ND
HARRISBURG-LEBANON-CARLISLE, PA	584,000	21	0.009	0.037	6	0.022	0.11	ND
HARTFORD, CT	748,000	30	0.011	0.046	9	0.020	**0.14**	0.09
HICKORY, NC	219,000	ND	ND	ND	ND	ND	ND	ND

PM10 = HIGHEST ARITHMETIC MEAN CONCENTRATION (Applicable NAAQS is 50 ug/m^3)
SO2 = HIGHEST ARITHMETIC MEAN CONCENTRATION (Applicable NAAQS is 0.03 ppm)
HIGHEST SECOND MAXIMUM 24-HOUR CONCENTRATION (Applicable NAAQS is 0.14 ppm)
CO = HIGHEST SECOND MAXIMUM NONOVERLAPPING 8-HOUR CONCENTRATION (Applicable NAAQS is 9 ppm)
NO2 = HIGHEST ARITHMETIC MEAN CONCENTRATION (Applicable NAAQS is 0.053 ppm)
O3 = HIGHEST SECOND DAILY MAXIMUM 1-HOUR CONCENTRATION (Applicable NAAQS is 0.12 ppm)
PB = HIGHEST QUARTERLY MAXIMUM CONCENTRATION (Applicable NAAQS is 1.15 ug/m^3)

ND = INDICATES DATA NOT AVAILABLE
IN = INDICATES INSUFFICIENT DATA TO CALCULATE SUMMARY STATISTIC

UGM = UNITS ARE MICROGRAMS PER CUBIC METER
PPM = UNITS ARE PARTS PER MILLION

* - Impact from an industrial source in Collin County, TX. Highest site in Dallas, TX is 0.42 ug/m3.

TABLE 4-3. 1989 METROPOLITAN STATISTICAL AREA (MSA) AIR QUALITY FACTBOOK
PEAK STATISTICS FOR SELECTED POLLUTANTS BY MSA

METROPOLITAN STATISTICAL AREA	1987 POPULATION	PM10 AM (UGM)	SO2 AM (PPM)	SO2 24-HR (PPM)	CO 8HR (PPM)	NO2 AM (PPM)	OZONE 2ND DMX (PPM)	PB QMAX (UGM)
HONOLULU, HI	831,000	IN	0.001	0.003	4	ND	0.05	0.04
HOUMA-THIBODAUX, LA	185,000	ND	ND	ND	ND	ND	0.11	ND
HOUSTON, TX	3,228,000	30	0.009	0.055	8	0.028	**0.23**	0.05
HUNTINGTON-ASHLAND, WV-KY-OH	323,000	42	0.017	0.085	6	0.013	0.12	0.06
HUNTSVILLE, AL	231,000	31	ND	ND	5	ND	0.09	ND
INDIANAPOLIS, IN	1,229,000	43	0.014	0.056	5	0.023	0.12	1.13*
IOWA CITY, IA	86,000	ND	ND	ND	ND	ND	0.09	ND
JACKSON, MI	147,000	ND	ND	ND	ND	ND	ND	ND
JACKSON, MS	396,000	26	ND	ND	6	ND	0.09	0.08
JACKSON, TN	78,000	30	ND	ND	ND	ND	ND	ND
JACKSONVILLE, FL	878,000	37	0.006	0.060	7	0.015	0.11	0.05
JACKSONVILLE, NC	126,000	ND	ND	ND	ND	ND	ND	ND
JANESVILLE-BELOIT, WI	135,000	ND	ND	ND	ND	ND	0.12	ND
JERSEY CITY, NJ	547,000	37	0.016	0.052	7	0.031	0.12	0.08
JOHNSON CITY-KINGSPORT-BRISTOL, TN-V	443,000	32	0.014	0.072	4	0.019	0.11	ND
JOHNSTOWN, PA	252,000	33	0.016	0.089	4	0.019	0.10	0.31
JOLIET, IL	377,000	33	0.007	0.031	ND	ND	0.10	0.03
JOPLIN, MO	134,000	ND	ND	ND	ND	ND	ND	ND
KALAMAZOO, MI	219,000	ND	ND	ND	ND	ND	ND	0.02
KANKAKEE, IL	98,000	ND	ND	ND	ND	ND	ND	ND
KANSAS CITY, MO-KS	1,546,000	47	0.006	0.020	7	0.015	0.11	0.11
KENOSHA, WI	120,000	ND	0.003	0.013	ND	0.016	**0.13**	ND
KILLEN-TEMPLE, TX	234,000	ND	ND	ND	ND	ND	ND	ND
KNOXVILLE, TN	594,000	35	0.013	0.051	7	ND	0.10	ND
KOKOMO, IN	101,000	ND	ND	ND	ND	ND	ND	ND
LA CROSSE, WI	95,000	ND	ND	ND	ND	ND	ND	ND
LAFAYETTE, LA	212,000	ND	ND	ND	ND	ND	0.10	ND
LAFAYETTE, IN	125,000	37	0.006	0.025	1	ND	0.09	ND
LAKE CHARLES, LA	172,000	IN	0.002	0.011	ND	ND	**0.13**	ND
LAKE COUNTY, IL	494,000	ND	ND	ND	ND	ND	**0.13**	ND
LAKELAND-WINTER HAVEN, FL	387,000	ND	0.004	0.016	ND	ND	ND	ND
LANCASTER, PA	404,000	29	0.007	0.037	4	0.018	0.10	0.05
LANSING-EAST LANSING, MI	428,000	IN	ND	ND	ND	ND	0.10	0.02
LAREDO, TX	124,000	IN	ND	ND	ND	ND	ND	ND
LAS CRUCES, NM	129,000	**68**	0.016	0.105	6	ND	0.11	0.17
LAS VEGAS, NV	600,000	**69**	ND	ND	**12**	IN	0.11	ND
LAWRENCE, KS	75,000	ND	ND	ND	ND	ND	ND	ND
LAWRENCE-HAVERHILL, MA-NH	375,000	ND	0.010	0.041	ND	ND	0.12	ND
LAWTON, OK	119,000	IN	0.010	0.039	ND	ND	ND	ND
LEWISTON-AUBURN, ME	85,000	ND	0.008	0.035	ND	ND	ND	0.03

LEXINGTON-FAYETTE, KY	342,000	ND	0.006	0.034	6	0.019	0.11	ND
LIMA, OH	156,000	ND	0.006	0.033	ND	ND	0.10	ND
LINCOLN, NE	208,000	34	ND	ND	8	ND	0.06	ND
LITTLE ROCK-NORTH LITTLE ROCK, AR	512,000	33	0.002	0.010	ND	0.009	0.09	0.34
LONGVIEW-MARSHALL, TX	167,000	ND	ND	ND	ND	ND	0.10	ND
LORAIN-ELYRIA, OH	268,000	IN	0.007	0.035	ND	ND	0.12	ND
LOS ANGELES-LONG BEACH, CA	8,505,000	**64**	0.005	0.021	**18**	**0.057**	**0.33**	0.14
LOUISVILLE, KY-IN	967,000	38	0.012	0.060	7	IN	0.11	0.07
LOWELL, MA-NH	260,000	ND	ND	ND	5	ND	ND	ND
LUBBOCK, TX	228,000	34	ND	ND	ND	ND	ND	ND
LYNCHBURG, VA	143,000	30	ND	ND	ND	ND	ND	ND
MACON-WARNER ROBINS, GA	283,000	ND	ND	ND	ND	ND	ND	ND
MADISON, WI	347,000	IN	0.003	0.016	5	ND	0.10	ND
MANCHESTER, NH	146,000	24	0.009	0.050	7	0.022	0.10	0.03
MANSFIELD, OH	128,000	ND	ND	ND	ND	ND	ND	ND
MAYAGUEZ, PR	210,000	ND	ND	ND	ND	ND	ND	ND
MCALLEN-EDINBURG-MISSION, TX	379,000	ND	ND	ND	ND	ND	ND	ND
MEDFORD, OR	143,000	**51**	ND	ND	**12**	ND	0.09	0.04
MELBOURNE-TITUSVILLE-PALM BAY, FL	375,000	ND	ND	ND	ND	ND	0.10	ND
MEMPHIS, TN-AR-MS	972,000	33	0.009	0.033	**10**	0.026	0.12	0.19
MERCED, CA	166,000	**52**	ND	ND	ND	ND	ND	ND
MIAMI-HIALEAH, FL	1,791,000	28	ND	ND	8	0.018	0.12	0.08
MIDDLESEX-SOMERSET-HUNTERDON, NJ	966,000	34	0.010	0.037	5	0.024	**0.13**	0.38
MIDDLETOWN, CT	85,000	23	ND	ND	ND	ND	**0.17**	ND
MIDLAND, TX	108,000	ND	ND	ND	ND	ND	ND	ND
MILWAUKEE, WI	1,389,000	40	0.007	0.032	6	0.029	**0.15**	0.07
MINNEAPOLIS-ST. PAUL, MN-WI	2,336,000	33	0.010	0.072	**11**	0.009	0.10	1.04#

PM10 = HIGHEST ARITHMETIC MEAN CONCENTRATION (Applicable NAAQS is 50 ug/m^3)
SO2 = HIGHEST ARITHMETIC MEAN CONCENTRATION (Applicable NAAQS is 0.03 ppm)
HIGHEST SECOND MAXIMUM 24-HOUR CONCENTRATION (Applicable NAAQS is 0.14 ppm)
CO = HIGHEST SECOND MAXIMUM NONOVERLAPPING 8-HOUR CONCENTRATION (Applicable NAAQS is 9 ppm)
NO2 = HIGHEST ARITHMETIC MEAN CONCENTRATION (Applicable NAAQS is 0.053 ppm)
O3 = HIGHEST SECOND DAILY MAXIMUM 1-HOUR CONCENTRATION (Applicable NAAQS is 0.12 ppm)
PB = HIGHEST QUARTERLY MAXIMUM CONCENTRATION (Applicable NAAQS is 1.15 ug/m^3)

ND = INDICATES DATA NOT AVAILABLE
IN = INDICATES INSUFFICIENT DATA TO CALCULATE SUMMARY STATISTIC

UGM = UNITS ARE MICROGRAMS PER CUBIC METER
PPM = UNITS ARE PARTS PER MILLION

* - Impact from an industrial source in Indianapolis, IN.

# - Impact from an industrial source in Eagan, MN. Highest site in Minneapolis, MN is 0.05 ug/m3.

TABLE 4-3. 1989 METROPOLITAN STATISTICAL AREA (MSA) AIR QUALITY FACTBOOK
PEAK STATISTICS FOR SELECTED POLLUTANTS BY MSA

METROPOLITAN STATISTICAL AREA	1987 POPULATION	PM10 AM (UGM)	SO2 AM (PPM)	SO2 24-HR (PPM)	CO 8HR (PPM)	NO2 AM (PPM)	OZONE 2ND DMX (PPM)	PB QMAX (UGM)
MOBILE, AL	483,000	37	0.008	0.063	ND	ND	0.10	ND
MODESTO, CA	327,000	**52**	0.001	0.010	**12**	0.027	**0.13**	ND
MONMOUTH-OCEAN, NJ	957,000	ND	ND	ND	6	ND	**0.14**	ND
MONROE, LA	146,000	IN	ND	ND	ND	ND	ND	ND
MONTGOMERY, AL	297,000	18	ND	ND	ND	ND	0.08	ND
MUNCIE, IN	121,000	IN	ND	ND	ND	ND	ND	ND
MUSKEGON, MI	159,000	IN	ND	ND	ND	ND	**0.14**	0.03
NAPLES, FL	128,000	ND	ND	ND	ND	ND	ND	ND
NASHUA, NH	172,000	24	0.008	0.042	8	ND	0.09	0.03
NASHVILLE, TN	956,000	IN	0.013	0.113	9	0.012	**0.14**	1.13*
NASSAU-SUFFOLK, NY	2,631,000	ND	0.012	0.050	7	0.029	**0.15**	0.03
NEW BEDFORD, MA	166,000	ND	ND	ND	ND	ND	0.12	ND
NEW BRITAIN, CT	147,000	24	0.009	0.048	ND	ND	ND	ND
NEW HAVEN-MERIDEN, CT	519,000	44	0.016	0.088	6	0.028	**0.15**	0.08
NEW LONDON-NORWICH, CT-RI	259,000	23	0.008	0.027	ND	ND	**0.14**	ND
NEW ORLEANS, LA	1,321,000	39	0.004	0.019	7	0.022	0.11	0.09
NEW YORK, NY	8,529,000	**66**	0.021	0.081	**12**	0.049	**0.13**	0.12
NEWARK, NJ	1,891,000	38	0.013	0.056	9	0.038	**0.13**	0.41
NIAGARA FALLS, NY	216,000	IN	0.014	0.059	4	ND	0.10	ND
NORFOLK-VIRGINIA BEACH-NEWPORT NEWS,	1,346,000	29	0.008	0.039	7	0.020	0.10	0.12
NORWALK, CT	126,000	37	ND	ND	ND	ND	ND	ND
OAKLAND, CA	1,968,000	37	0.003	0.017	6	0.025	**0.13**	0.21
OCALA, FL	181,000	ND	ND	ND	ND	ND	ND	ND
ODESSA, TX	127,000	IN	ND	ND	ND	ND	ND	ND
OKLAHOMA CITY, OK	975,000	27	0.006	0.016	9	0.015	0.11	0.07
OLYMPIA, WA	151,000	28	ND	ND	ND	ND	ND	ND
OMAHA, NE-IA	616,000	46	0.002	0.008	7	ND	0.10	**2.13#**
ORANGE COUNTY, NY	288,000	IN	ND	ND	ND	ND	ND	1.36@
ORLANDO, FL	935,000	32	0.002	0.006	5	0.013	0.11	0.02
OWENSBORO, KY	88,000	IN	0.010	0.053	6	0.014	0.10	0.05
OXNARD-VENTURA, CA	628,000	40	0.001	0.007	4	0.027	**0.17**	0.04
PANAMA CITY, FL	122,000	ND	ND	ND	ND	ND	ND	ND
PARKERBURG-MARIETTA, WV-OH	156,000	ND	0.016	0.076	ND	ND	0.12	0.04
PASCAGOULA, MS	128,000	ND	0.006	0.021	ND	ND	0.10	ND
PAWTUCKET-WOONSOCKET-ATTLEBORO, RI-M	322,000	32	0.011	0.040	ND	ND	ND	ND
PENSACOLA, FL	344,000	ND	0.006	0.057	ND	ND	0.09	ND
PEORIA, IL	339,000	28	0.007	0.056	8	ND	0.11	0.04
PHILADELPHIA, PA-NJ	4,866,000	46	0.015	0.065	**12**	0.040	**0.16**	0.41
PHOENIX, AZ	1,960,000	**70**	0.002	0.006	**13**	ND	0.11	0.10
PINE BLUFF, AR	91,000	IN	ND	ND	ND	ND	ND	ND

PITTSBURGH, PA	2,105,000	43	0.024	0.106	8	0.028	**0.13**	0.10
PITTSFIELD, MA	80,000	ND	ND	ND	ND	ND	0.09	ND
PONCE, PR	235,000	46	ND	ND	ND	ND	ND	ND
PORTLAND, ME	210,000	24	0.010	0.039	4	ND	**0.13**	0.05
PORTLAND, OR-WA	1,168,000	33	0.007	0.023	**10**	IN	0.09	0.11
PORTSMOUTH-DOVER-ROCHESTER, NH-ME	215,000	IN	0.008	0.029	ND	ND	0.11	0.04
POUGHKEEPSIE, NY	258,000	ND	0.009	0.042	ND	ND	0.08	ND
PROVIDENCE, RI	643,000	39	0.015	0.047	8	0.024	**0.13**	0.21
PROVO-OREM, UT	242,000	**52**	ND	ND	**16**	0.028	0.11	ND
PUEBLO, CO	127,000	33	ND	ND	ND	ND	ND	ND
RACINE, WI	173,000	ND	ND	ND	6	ND	**0.14**	ND
RALEIGH-DURHAM, NC	665,000	30	ND	ND	**11**	0.012	0.11	ND
RAPID CITY, SD	80,000	IN	ND	ND	ND	ND	ND	ND
READING, PA	324,000	IN	0.010	0.045	5	0.023	0.11	0.31
REDDING, CA	136,000	IN	ND	ND	2	0.014	0.09	ND
RENO, NV	232,000	47	ND	ND	**10**	ND	0.10	ND
RICHLAND-KENNEWICK-PASCO, WA	150,000	29	ND	ND	ND	ND	ND	ND
RICHMOND-PETERSBURG, VA	825,000	30	0.014	0.085	4	0.025	0.11	ND
RIVERSIDE-SAN BERNARDINO, CA	2,119,000	**93**	0.004	0.023	8	0.045	**0.28**	0.08
ROANOKE, VA	224,000	IN	0.005	0.022	2	0.014	0.10	ND
ROCHESTER, MN	98,000	IN	0.004	0.028	6	ND	ND	ND
ROCHESTER, NY	979,000	IN	0.016	0.069	4	ND	0.11	0.03
ROCKFORD, IL	281,000	IN	ND	ND	7	ND	0.10	0.07
SACRAMENTO, CA	1,336,000	43	0.006	0.020	**13**	0.025	**0.14**	0.08
SAGINAW-BAY CITY-MIDLAND, MI	404,000	29	0.008	0.061	2	0.009	ND	0.03
ST. CLOUD, MN	177,000	17	0.002	0.011	5	ND	ND	ND
ST. JOSEPH, MO	85,000	45	0.003	0.037	ND	ND	ND	ND

PM10 = HIGHEST ARITHMETIC MEAN CONCENTRATION (Applicable NAAQS is 50 ug/m^3)
SO2 = HIGHEST ARITHMETIC MEAN CONCENTRATION (Applicable NAAQS is 0.03 ppm)
HIGHEST SECOND MAXIMUM 24-HOUR CONCENTRATION (Applicable NAAQS is 0.14 ppm)
CO = HIGHEST SECOND MAXIMUM NONOVERLAPPING 8-HOUR CONCENTRATION (Applicable NAAQS is 9 ppm)
NO2 = HIGHEST ARITHMETIC MEAN CONCENTRATION (Applicable NAAQS is 0.053 ppm)
O3 = HIGHEST SECOND DAILY MAXIMUM 1-HOUR CONCENTRATION (Applicable NAAQS is 0.12 ppm)
PB = HIGHEST QUARTERLY MAXIMUM CONCENTRATION (Applicable NAAQS is 1.15 ug/m^3)

ND = INDICATES DATA NOT AVAILABLE
IN = INDICATES INSUFFICIENT DATA TO CALCULATE SUMMARY STATISTIC

UGM = UNITS ARE MICROGRAMS PER CUBIC METER
PPM = UNITS ARE PARTS PER MILLION

* - Impact from an industrial source in Williamson County, TN. Highest site in Nashville, TN is 0.16 ug/m3.

- Impact from an industrial source in Omaha, NE.

@ - Impact from an industrial source in Orange County, NY.

TABLE 4-3. 1989 METROPOLITAN STATISTICAL AREA (MSA) AIR QUALITY FACTBOOK PEAK STATISTICS FOR SELECTED POLLUTANTS BY MSA

METROPOLITAN STATISTICAL AREA	1987 POPULATION	PM10 AM (UGM)	SO2 AM (PPM)	SO2 24-HR (PPM)	CO 8HR (PPM)	NO2 AM (PPM)	OZONE 2ND DMX (PPM)	PB QMAX (UGM)
ST. LOUIS, MO-IL	2,458,000	**76**	0.018	0.102	8	0.026	**0.13**	**2.29**•
SALEM, OR	266,000	ND	ND	ND	4	ND	ND	ND
SALEM-GLOUCESTER, MA	258,000	ND	0.009	0.040	ND	ND	ND	ND
SALINAS-SEASIDE-MONTEREY, CA	343,000	25	0.001	0.002	2	0.014	0.11	ND
SALT LAKE CITY-OGDEN, UT	1,055,000	**56**	0.019	0.103	8	0.034	**0.15**	0.15
SAN ANGELO, TX	99,000	ND	ND	ND	ND	ND	ND	ND
SAN ANTONIO, TX	1,307,000	28	ND	ND	7	ND	0.11	0.04
SAN DIEGO, CA	2,286,000	44	0.006	0.018	**10**	0.032	**0.19**	0.07
SAN FRANCISCO, CA	1,590,000	36	0.003	0.015	8	0.026	0.09	0.15
SAN JOSE, CA	1,415,000	41	ND	ND	**12**	0.032	**0.13**	0.14
SAN JUAN, PR	1,541,000	IN	0.003	0.019	6	ND	0.06	0.05
SANTA BARBARA-SANTA MARIA-LOMPOC, CA	341,000	34	0.002	0.010	7	0.027	**0.16**	0.05
SANTA CRUZ, CA	222,000	IN	0.001	0.004	1	0.009	0.08	ND
SANTA FE, NM	111,000	16	ND	ND	4	ND	0.05	ND
SANTA ROSA-PETALUMA, CA	354,000	27	ND	ND	5	0.015	0.10	0.07
SARASOTA, FL	256,000	ND	0.003	0.017	6	ND	0.10	ND
SAVANNAH, GA	241,000	ND	0.003	0.016	ND	ND	ND	ND
SCRANTON-WILKES-BARRE, PA	731,000	32	0.009	0.048	5	0.021	0.11	ND
SEATTLE, WA	1,796,000	40	0.007	0.023	**10**	ND	0.09	0.31
SHARON, PA	123,000	IN	0.011	0.043	ND	ND	0.11	ND
SHEBOYGAN, WI	102,000	ND	0.004	0.015	ND	ND	0.11	ND
SHERMAN-DENISON, TX	100,000	ND	ND	ND	ND	ND	ND	ND
SHREVEPORT, LA	364,000	IN	0.004	0.023	ND	ND	0.12	ND
SIOUX CITY, IA-NE	115,000	28	ND	ND	ND	ND	ND	ND
SIOUX FALLS, SD	124,000	22	ND	ND	ND	ND	ND	ND
SOUTH BEND-MISHAWAKA, IN	242,000	IN	0.006	0.026	4	ND	0.10	ND
SPOKANE, WA	355,000	44	ND	ND	**12**	ND	ND	ND
SPRINGFIELD, IL	191,000	IN	0.007	0.047	4	ND	0.11	ND
SPRINGFIELD, MO	229,000	22	0.009	0.073	7	0.010	0.09	ND
SPRINGFIELD, MA	517,000	31	0.013	0.055	9	0.029	**0.13**	0.06
STAMFORD, CT	193,000	26	0.011	0.047	6	ND	**0.16**	ND
STATE COLLEGE, PA	115,000	ND	ND	ND	ND	ND	ND	ND
STEUBENVILLE-WEIRTON, OH-WV	149,000	45	**0.035**	0.127	**13**	0.023	0.11	0.00
STOCKTON, CA	443,000	**51**	IN	0.007	**10**	0.026	0.11	0.05
SYRACUSE, NY	647,000	28	0.005	0.020	**10**	ND	0.10	0.04
TACOMA, WA	545,000	39	0.007	0.033	**10**	ND	0.09	0.04
TALLAHASSEE, FL	223,000	ND	ND	ND	ND	ND	0.07	ND
TAMPA-ST. PETERSBURG-CLEARWATER, FL	1,965,000	32	0.011	0.039	6	0.022	0.10	0.13
TERRE HAUTE, IN	132,000	34	0.009	0.046	ND	ND	0.11	ND
TEXARKANA, TX-AR	120,000	IN	ND	ND	ND	ND	ND	ND

TOLEDO, OH	611,000	IN	0.008	0.050	5	ND	0.11	0.48
TOPEKA, KS	162,000	IN	ND	ND	ND	ND	ND	0.03
TRENTON, NJ	327,000	30	0.009	0.040	5	ND	**0.14**	ND
TUCSON, AZ	619,000	**52**	0.002	0.008	7	0.023	0.10	0.06
TULSA, OK	733,000	36	0.007	0.038	7	0.020	0.12	0.20
TUSCALOOSA, AL	144,000	IN	ND	ND	ND	ND	ND	ND
TYLER, TX	153,000	ND	ND	ND	ND	ND	ND	ND
UTICA-ROME, NY	314,000	ND	ND	ND	ND	ND	0.09	ND
VALLEJO-FAIRFIELD-NAPA, CA	404,000	32	0.002	0.010	**10**	0.019	0.11	0.10
VANCOUVER, WA	216,000	ND	IN	0.011	**10**	ND	0.09	ND
VICTORIA, TX	75,000	ND	ND	ND	ND	ND	0.10	ND
VINELAND-MILLVILE-BRIDGETON, NJ	138,000	ND	0.008	0.049	ND	ND	**0.13**	ND
VISALIA-TULARE-PORTERVILLE, CA	292,000	**67**	IN	0.006	6	0.021	**0.15**	ND
WACO, TX	189,000	ND	ND	ND	ND	ND	ND	ND
WASHINGTON, DC-MD-VA	3,646,000	43	0.014	0.046	9	0.031	**0.13**	0.10
WATERBURY, CT	213,000	33	0.011	0.064	ND	ND	ND	0.06
WATERLOO-CEDAR FALLS, IA	149,000	ND	ND	ND	ND	ND	ND	ND
WAUSAU, WI	111,000	ND	0.010	0.074	ND	ND	ND	ND
WEST PALM BEACH-BOCA RATON-DELRAY BE	790,000	IN	0.003	0.008	4	0.013	0.11	ND
WHEELING, WV-OH	173,000	34	0.026	0.076	5	0.019	0.11	0.07
WICHITA, KS	475,000	31	ND	ND	9	ND	0.09	0.04
WICHITA FALLS, TX	126,000	IN	ND	ND	ND	ND	ND	ND
WILLIAMSPORT, PA	117,000	29	0.007	0.042	ND	ND	0.08	ND
WILMINGTON, DE-NJ-MD	559,000	35	0.018	0.049	5	0.034	**0.13**	0.16
WILMINGTON, NC	116,000	27	ND	ND	ND	ND	ND	ND
WORCESTER, MA	410,000	27	0.010	0.040	8	0.026	0.10	ND
YAKIMA, WA	183,000	IN	ND	ND	9	ND	ND	ND
YORK, PA	404,000	31	0.007	0.035	5	0.022	0.10	ND
YOUNGSTOWN-WARREN, OH	503,000	35	0.010	0.041	ND	ND	0.11	ND
YUBA CITY, CA	116,000	IN	ND	ND	ND	ND	0.10	ND

PM10 = HIGHEST ARITHMETIC MEAN CONCENTRATION (Applicable NAAQS is 50 ug/m^3)
SO2 = HIGHEST ARITHMETIC MEAN CONCENTRATION (Applicable NAAQS is 0.03 ppm)
HIGHEST SECOND MAXIMUM 24-HOUR CONCENTRATION (Applicable NAAQS is 0.14 ppm)
CO = HIGHEST SECOND MAXIMUM NONOVERLAPPING 8-HOUR CONCENTRATION (Applicable NAAQS is 9 ppm)
NO2 = HIGHEST ARITHMETIC MEAN CONCENTRATION (Applicable NAAQS is 0.053 ppm)
O3 = HIGHEST SECOND DAILY MAXIMUM 1-HOUR CONCENTRATION (Applicable NAAQS is 0.12 ppm)
PB = HIGHEST QUARTERLY MAXIMUM CONCENTRATION (Applicable NAAQS is 1.15 ug/m^3)

ND = INDICATES DATA NOT AVAILABLE
IN = INDICATES INSUFFICIENT DATA TO CALCULATE SUMMARY STATISTIC

UGM = UNITS ARE MICROGRAMS PER CUBIC METER
PPM = UNITS ARE PARTS PER MILLION

* - Impact from a lead smelter in Herculaneum, MO. Highest site in St. Louis, MO is 0.23 ug/m3.

5. SELECTED METROPOLITAN AREA TRENDS

This chapter discusses 1980-89 air quality trends in major urban areas. The cities for which trends are presented include: the ten EPA Regional Offices (Boston, New York, Philadelphia, Atlanta, Chicago, Dallas, Kansas City, Denver, San Francisco, and Seattle) plus four additional cities (Houston, Los Angeles, Pittsburgh, and Washington, DC.)

The presentation of urban area trends includes maps of the urban area showing their major roadways, rivers, etc. as well as the location of the air quality monitoring networks. Various new graphical displays are used to depict urban air quality trends. These are primarily based on the Pollutant Standards Index (PSI) as the measure of air quality.

The air quality data used for the trend statistics were obtained from the EPA Aerometric Information and Retrieval System (AIRS). This year's report analyzes trends using the PSI, which is used locally in many areas to characterize and publicly report air quality. The new PSI analyses will be based on daily maximum statistics from selected monitoring sites. The urban area trends for CO and O_3 use the same annual validity and site selection criteria that were used for the national trends. It should be noted that no interpolation is used in this chapter; this corresponds with typical PSI reporting.

5.1 The Pollutant Standards Index

The PSI is used as an air quality indicator for describing urban area trends. Only CO and O_3 monitoring sites with adequate historical data are included in these PSI trend analyses. This criteria was not applied to the other pollutants, except for SO_2 in Pittsburgh, where this pollutant contributed a significant number of days in the high PSI range. Results for individual years could be somewhat different if data from all monitoring sites and all pollutants were considered in an area. This is illustrated for 1989, for which the number of PSI days from all monitoring sites are compared to the results for the subset of trend sites.

The PSI has found wide spread use in the air pollution field as a means of reporting daily air quality to the general public. The index integrates information from many pollutants across an entire monitoring network into a single number which represents the worst daily air quality experienced in the urban area. The PSI is computed for PM_{10}, SO_2, CO, O_3, and NO_2 based on their short-term NAAQS, Federal Episode Criteria and Significant Harm Levels. Lead is the only criteria pollutant which is not part of the index since it does not have either a short-term NAAQS, Federal Episode Criteria or Significant Harm Level.

The PSI converts daily monitoring information into a single measure of air quality by first computing a separate sub-index for each pollutant

Table 5-1. PSI Categories and Health Effect Descriptor Words

INDEX RANGE	DESCRIPTOR WORDS
0 to 50	Good
51 to 100	Moderate
101 to 199	Unhealthful
200 to 299	Very Unhealthful
300 and Above	Hazardous

with data for the day. The PSI index value used in this analysis represents the highest of the pollutant sub-index values for all sites selected for the MSA. This approach is different from the way the index is routinely used by most local agencies. Usually only selected monitoring sites are used to determine the PSI value.

The PSI simplifies the presentation of air quality data by producing a single dimensionless number ranging from 0 to 500. The PSI utilizes data from all selected sites in the MSA and combines different air pollutants with different averaging times, different units of concentration, and more importantly, with different NAAQS, Federal Episode Criteria and Significant Harm Levels. Table 5-1 shows the 5 PSI categories and health effect descriptor words. The PSI is primarily used to report the daily air quality of a large urban area as a single number or descriptor word. Frequently, the index is reported as a regular feature on local TV or radio news programs or in newspapers.

Throughout this section, emphasis is placed on CO and O_3, since they cause most of the NAAQS violations in urban areas.

5.2 Summary of PSI Analyses

Table 5-2 shows the number of PSI days greater than 100 (unhealthful or worse days). The impact of the very hot and dry summers in 1983 and 1988 in the eastern United States on O_3 concentrations can clearly be seen. Only in the case of Pittsburgh is there a significant number of these days for pollutants other than CO or O_3. For Pittsburgh, SO_2 and PM_{10} account for the additional days. The two right most columns show the total number of currently active monitoring sites and the corresponding total number of PSI days > 100, using these sites. Note that for all urban areas except Houston and New York there is close agreement between both 1989 estimates. The differences are attributed to currently active sites not in the trends analysis.

For all practical purposes CO, O_3, PM_{10} and SO_2 are the only pollutants which contribute to the PSI in these analyses. NO_2 rarely is a factor because it doesn't have a short-term NAAQS and it can only be included when concentrations exceed one of the Federal Episode Criteria or Significant Harm levels. TSP is not included in the index because it no longer is a criteria pollutant. Lead is the only criteria pollutant which is not considered in the index, since it does not have neither a short-term NAAQS nor Federal Criteria and Significant Harm Levels.

The pollutant having the highest sub-index value, from all the monitoring sites considered in an MSA, becomes the PSI value used for that day. Our PSI estimates vary with the number of pollutants monitored and with the number of monitoring sites collecting data. Therefore, the more pollutants and sites that are available in an area, the better the estimate is of the maximum PSI for that day. Ozone accounts for most of the days with a PSI above 100, and O_3 air quality is reasonably uniform over large areas. Thus, a small number of sites can still estimate maximum pollutant concentrations. All of the included cities had at least one trend site for both CO and O_3. Table 5-3 separately shows the number of CO and O_3 trend sites used in each of the MSA's. The PSI trend analyses are presented for the Primary MSA's (PMSA) in all cities studied, not the larger Consolidated Metropolitan Statistical Area (CMSA). Looking at only the principal PMSA was done to limit the geographical area studied and to emphasize the area having the highest population density. For the San Francisco area, some results for the Oakland PMSA are also presented. The PMSA monitors are in the core of the urban area; there are typically additional sites in surrounding areas. For example, while there are 18 active monitors in the Los Angeles PMSA in 1989, there are more than 30 monitors for ozone alone in the larger metropolitan area.

There are a number of assumptions that are implicit in the PSI analysis. Probably the most important is that the monitoring data available for a given area provide a reasonable estimate of maximum short-term concentration levels. The PSI

Note: Urban lead concentrations have dropped precipitously over the past 15 or so years (See Chapter 3). As a result, only 4 urban areas in 1989 violate the lead NAAQS. Dallas is the only one of the 14 urban areas which has a 1989 lead violation. In this case, the problem occurred near a smelter located outside of Dallas County, in adjoining Collin County.

Table 5-2. Number of PSI Days Greater than 100 at trend sites, 1980-89, and all sites in 1989.

		Number of PSI Days Greater than 100 at Trend Sites									
		YEAR									
PMSA	# trend sites	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
ATLANTA	3	7	9	5	23	8	9	17	19	15	3
BOSTON	3	8	2	5	16	6	2	0	5	11	1
CHICAGO	6	34	9	32	42	19	6	5	9	18	2
DALLAS	3	10	12	11	17	10	12	5	6	3	3
DENVER	3	35	51	48	64	51	32	42	33	15	10
HOUSTON	4	10	32	18	33	23	19	24	20	25	12
KANSAS CITY	7	13	7	0	4	12	4	8	5	3	2
LOS ANGELES	11	220	228	195	183	205	189	208	185	218	206
NEW YORK	8	119	100	69	65	53	21	16	16	35	9
PHILADELPHIA	13	52	26	36	52	26	25	20	33	34	18
PITTSBURGH	7	20	17	14	36	24	6	9	15	31	11
SAN FRANCISCO	3	2	1	2	4	2	5	4	1	1	0
SEATTLE	7	33	42	19	19	4	26	18	13	8	4
WASHINGTON	12	38	17	21	51	24	14	10	23	34	7
TOTAL	92	601	553	475	609	467	370	386	383	451	288

All active monitoring sites in PMSA 1989	
total # sites	PSI > 100
14	3
20	3
44	2
20	3
17	11
19	37
21	2
18	213
24	39
27	19
32	11
5	0
26	7
24	7
311	357

Table 5-3. Number of Trend Monitoring Sites for the 14 Urban Area Analyses

Primary Metropolitan Statistical Area (PMSA)	CO Sites	O_3 Sites
Atlanta, GA	1	2
Boston, MA	2	1
Chicago, IL	3	4
Dallas, TX	1	2
Denver, CO	3	2
Houston, TX	3	2
Kansas City, MO-KS	3	5
Los Angeles, CA	10	11
New York, NY	3	5
Philadelphia, PA	8	9
Pittsburgh, PA	2	5
San Francisco, CA	3	2
Seattle, WA	6	1
Washington, DC-MD-VA	8	11

procedure uses the maximum concentration even though it does not represent the air pollution exposure for the entire area. However, when the downwind maximum concentration site is outside the PMSA, these data are not used. Finally, the PSI assumes that synergism does not exist between pollutants. Each pollutant is examined independently. Combining pollutant concentrations together is not possible at this time because the synergistic effects are not known.

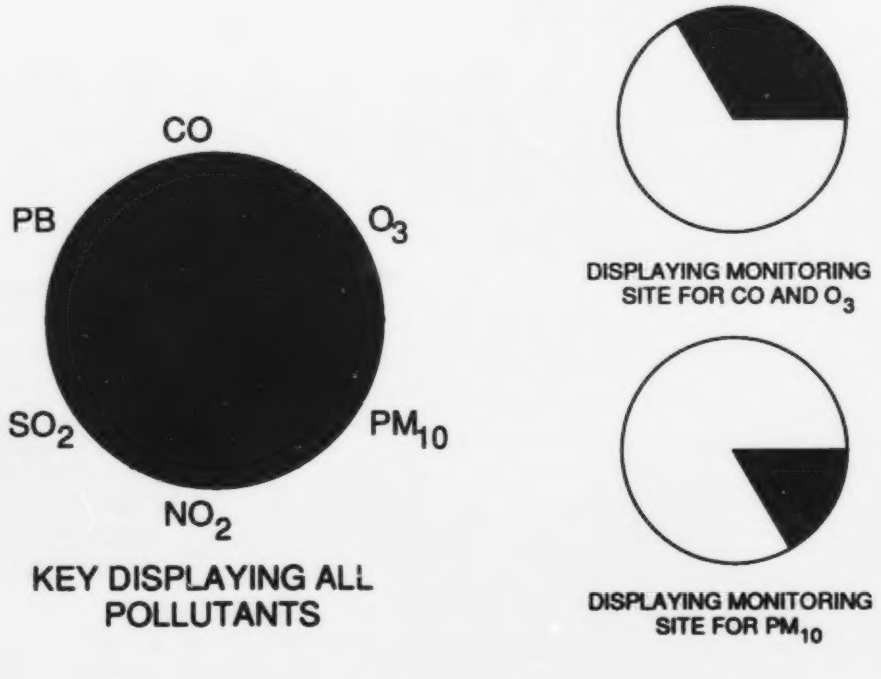
5.3 Description of Graphics

Each of the fourteen cities have all of the graphics and explanatory text presented on facing pages. The first page will include a map of the area highlighting the location of the current ambient monitoring network as well as other important features like rivers, lakes, and major highways. At each site, the shaded pie wedges of a circle identify the pollutants monitored in 1989. Circles with four tick marks denote trend sites.

Figure 5-1 identifies the shaded wedges corresponding to particular pollutants. The pollutants generally associated with transportation sources (CO, O_3 and Lead) are found on the upper half of the circle, while the other pollutants (PM_{10}, SO_2, and NO_2) are on the lower half. The accompanying graphs are based on the PSI methodology described earlier. The PSI graphs feature a bar chart which shows the number of PSI days in four PSI categories: 0-50, 51-100, 101-199 and $\geq$200. Table 5-1 shows the PSI descriptor words associated with these categories. Since there were so few days in the hazardous category, the very unhealthful and hazardous categories were combined. The total number of unhealthful, very unhealthful and hazardous days will be used as a parameter with which to track trends. It is important to note that a PSI of 100 means that the pollutant with the highest sub-index value is at the level of its NAAQS.

Because of numerical rounding, the number of days with PSI > 100 does not necessarily correspond to the number of NAAQS exceedances. A cumulative plot is shown for the trend in the number of days with a PSI > 100 (unhealthful days or worse) associated with CO and O_3. As mentioned earlier, other pollutants may contribute to additional PSI days > 100. In some areas, most notably Pittsburgh, the total of the days shown for CO and O_3 does not represent all of the PSI days > 100 (see table 5-2). SO_2 accounts for most of these additional days in Pittsburgh. Other areas with PSI>100 days attributable to pollutants other than CO or O_3 are: Chicago, Kansas City, and Seattle.

Also shown are the trends in average daily maximum 1-hr concentrations for O_3 and average daily maximum 8-hour concentrations for CO, by various temperature categories. Maximum daily temperatures are used for O_3 and minimum daily temperatures are used for CO. The O_3 temperature categories are: greater than or equal to 90, 80 to 89, 70 to 79 and less than 70, all in degrees Fahrenheit. The CO temperature categories are: greater than 40 and less than or equal to 40 degrees Fahrenheit. These plots are an attempt to factor out the impact of temperature, an important meteorological variable. Concentrations of both CO and O_3 are related either directly or indirectly to temperature. Ozone levels are highest in the summer, especially on very hot stagnant days, while CO is highest usually in the winter months. The New York MSA is one exception; it appears that higher temperatures are associated with higher CO levels. To complement the ozone analyses, a graph of the annual number of days greater than 90° is also included. The following sections present the metropolitan areas analyses.

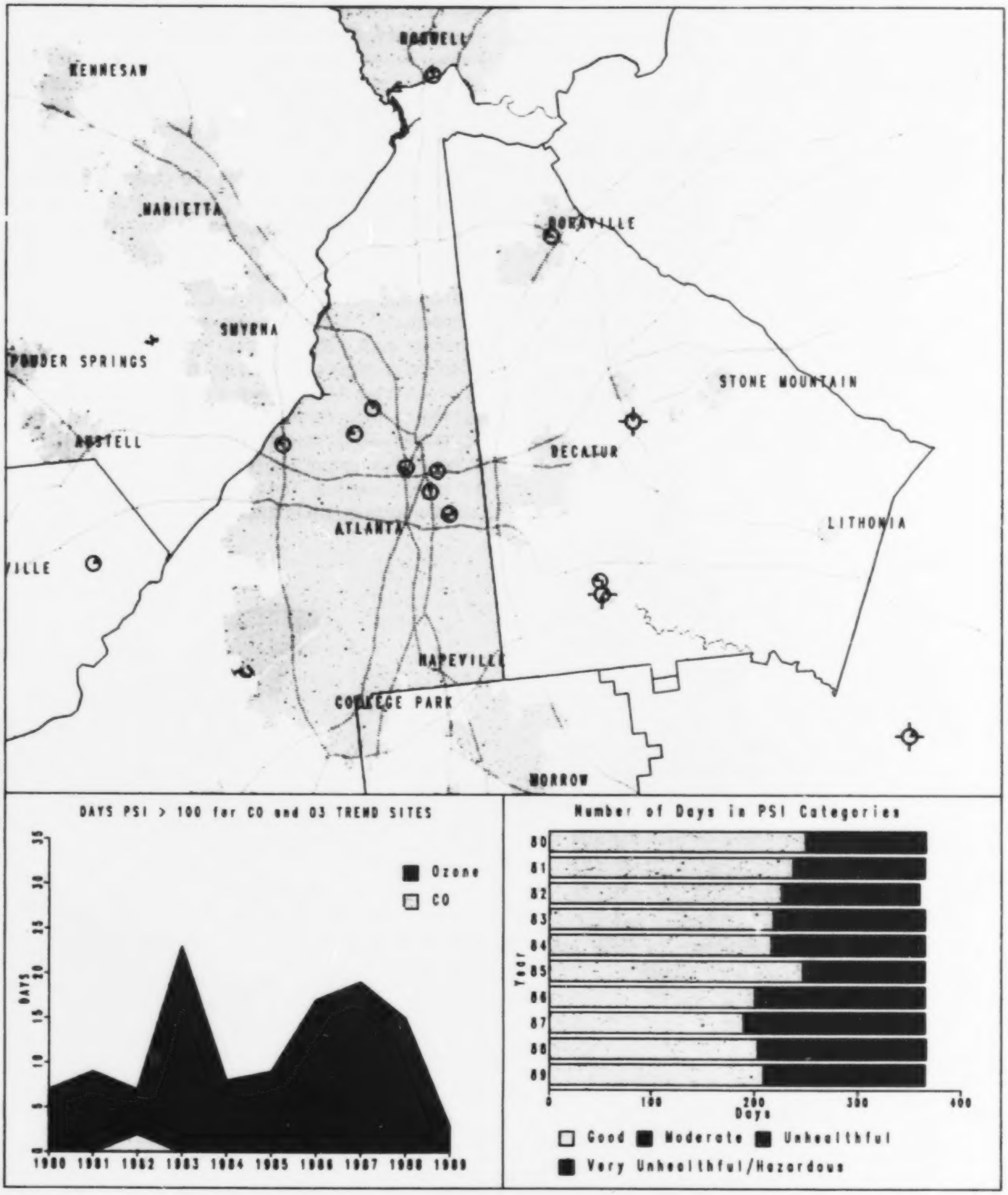


KEY DISPLAYING ALL POLLUTANTS

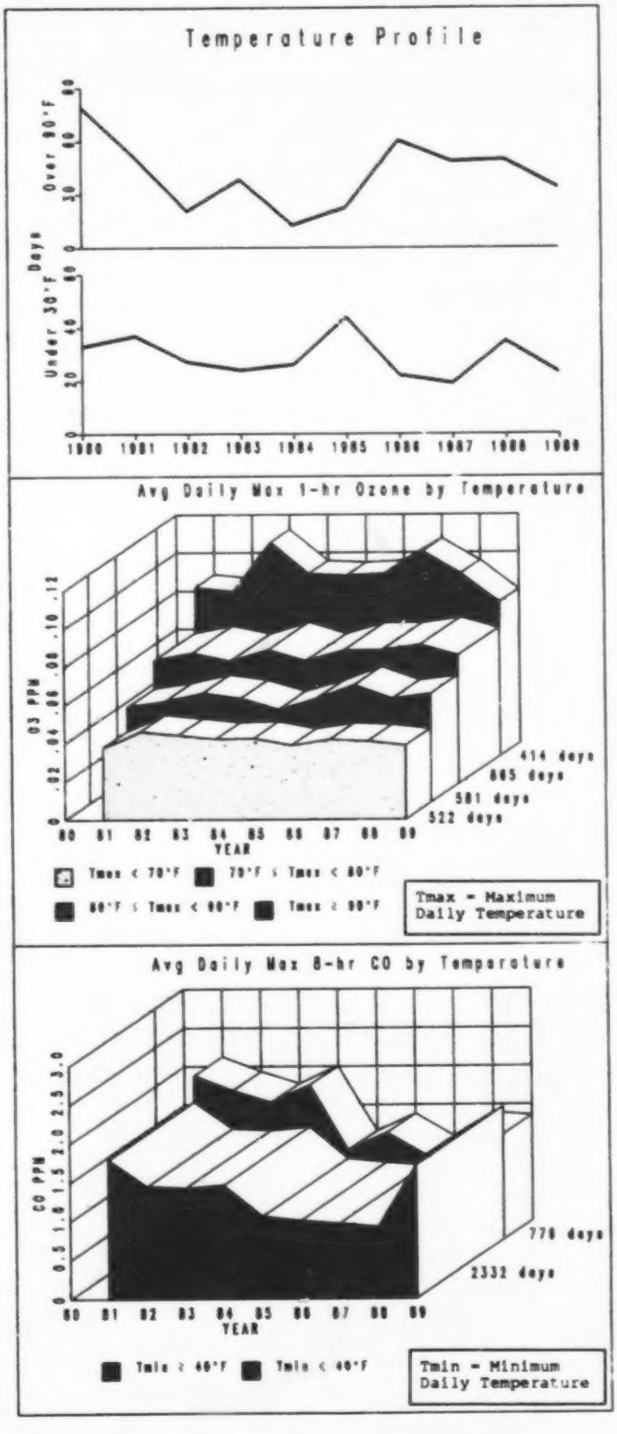
DISPLAYING MONITORING SITE FOR CO AND O_3

DISPLAYING MONITORING SITE FOR PM_{10}

Figure 5-1. Shaded wedges identifying pollutants monitored shown on metropolitan area maps.


ROSWELL
KENNESAW
MARIETTA
DORAVILLE
SMYRNA
POWDER SPRINGS
STONE MOUNTAIN
AUSTELL
DECATUR
ATLANTA
LITHONIA
VILLE
HAPEVILLE
COLLEGE PARK
MORROW
DAYS PSI > 100 for CO and O3 TREND SITES
Ozone
CO
DAYS
0
5
10
15
20
25
30
35
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
Number of Days in PSI Categories
Year
80
81
82
83
84
85
86
87
88
89
Days
0
100
200
300
400
Good
Moderate
Unhealthful
Very Unhealthful/Hazardous

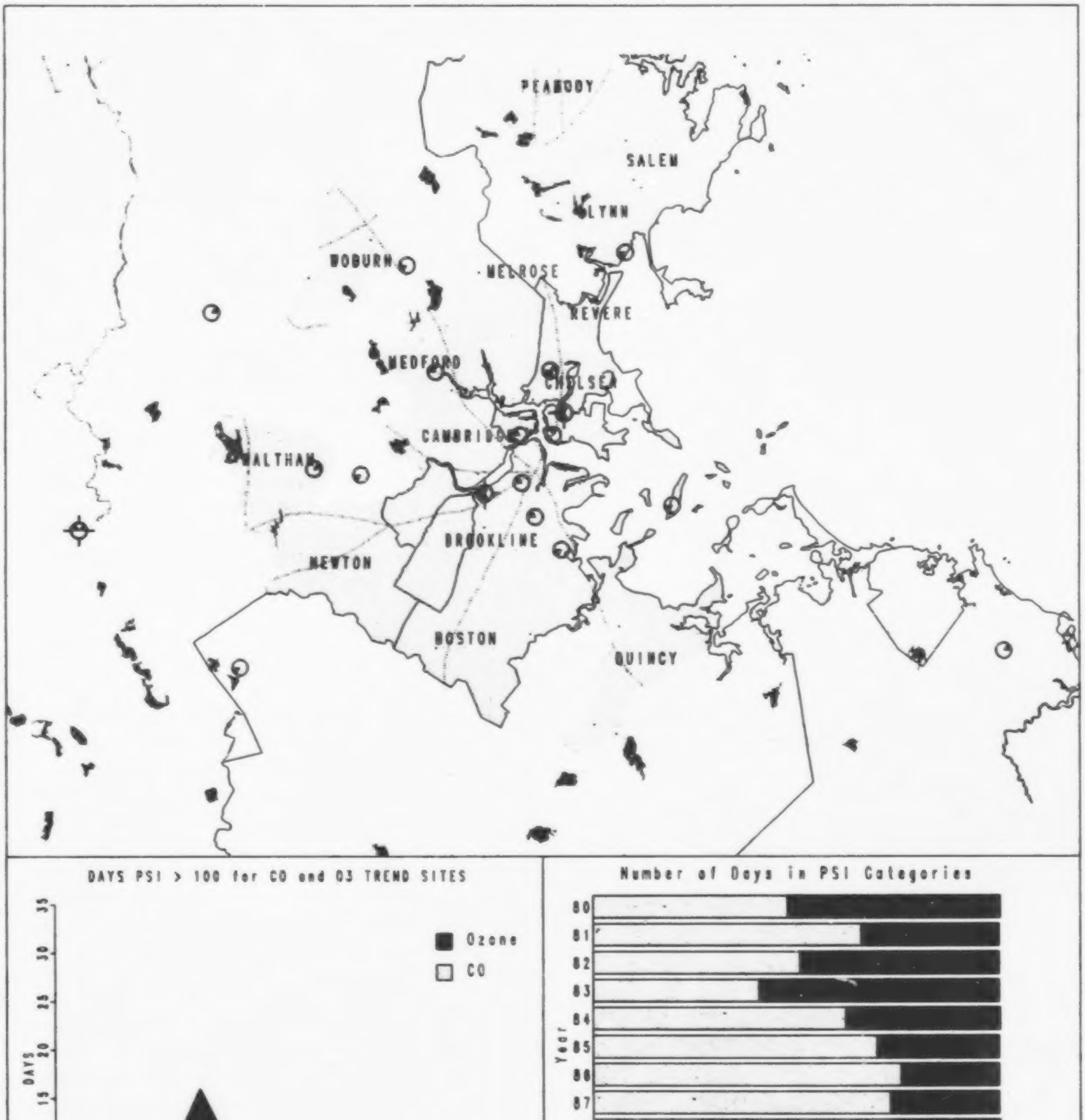
Atlanta, GA

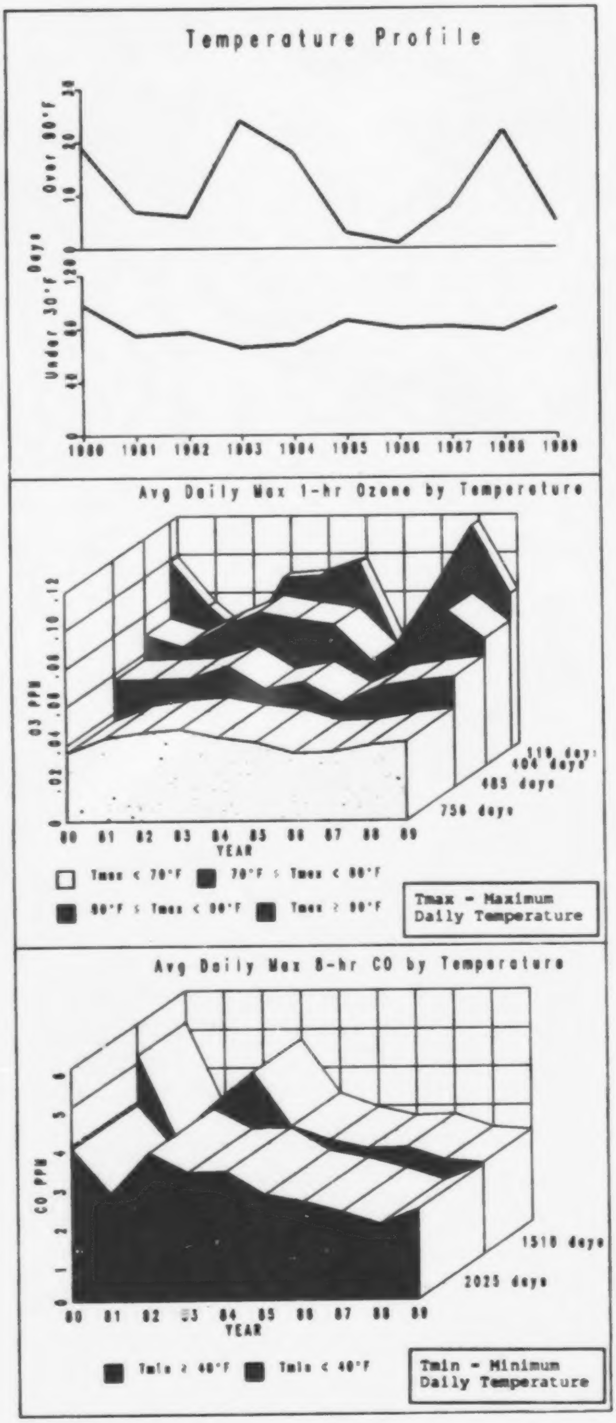


The Atlanta PMSA consists of 18 counties, with the majority of the people residing in Fulton, Dekalb, and Cobb Counties. The estimated 1988 population was 2.7 million. Its size and summertime meteorology contribute to the area's air pollution potential. The Bermuda High has a dominant effect on Atlanta's air quality, especially during the summer when the hot stagnant days are conducive to O_3 formation. The map shows 14 currently active monitoring sites.

The PSI trend for Atlanta is based on 3 sites: 1 for CO and 2 for O_3. The CO site is a population exposure site located in Dekalb County. The O_3 sites are a maximum concentration site in Rockdale County and a population exposure site in Dekalb County. Ozone is the pollutant in Atlanta which causes most of the unhealthful days. The number of days with an unhealthful or worse rating ranges from 23 days in 1983 to a low of 3 days in 1989. In the 10-year period only 1 day (in 1987) had a value in the very unhealthful range.

The average CO and O_3 concentrations by temperature follow the expected pattern: O_3 levels are highest on the hotter days and CO levels are higher on colder days. Average CO concentrations have dropped in both temperature classes. The sudden upturn in 1989 in the highest temperature category results from higher CO levels in the August-December period. CO levels average 3 times higher in this period compared to the other months in 1989. CO levels are very low for Atlanta, because trend data were not available from the maximum concentration site. Sufficient CO and O_3 data were not reported for 1980. Otherwise, the trend for O_3 in the hottest temperature category resembles the PSI trends, with highest average values in 1983 and 1987. The trend in average O_3 concentrations in the hottest category shows little change, while the trend in the two intermediate temperature categories show a small gradual increase over the ten years.


PEABODY
SALEM
LYNN
WOBURN
MELROSE
REVERE
MEDFORD
CHELSEA
CAMBRIDGE
WALTHAM
BROOKLINE
NEWTON
BOSTON
QUINCY
DAYS PSI > 100 for CO and O3 TREND SITES
DAYS
0
5
10
15
20
25
30
35
Ozone
CO
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
Number of Days in PSI Categories
Year
80
81
82
83
84
85
86
87
88
89
0
100
200
300
400
Days
Good
Moderate
Unhealthful
Very Unhealthful/Hazardous

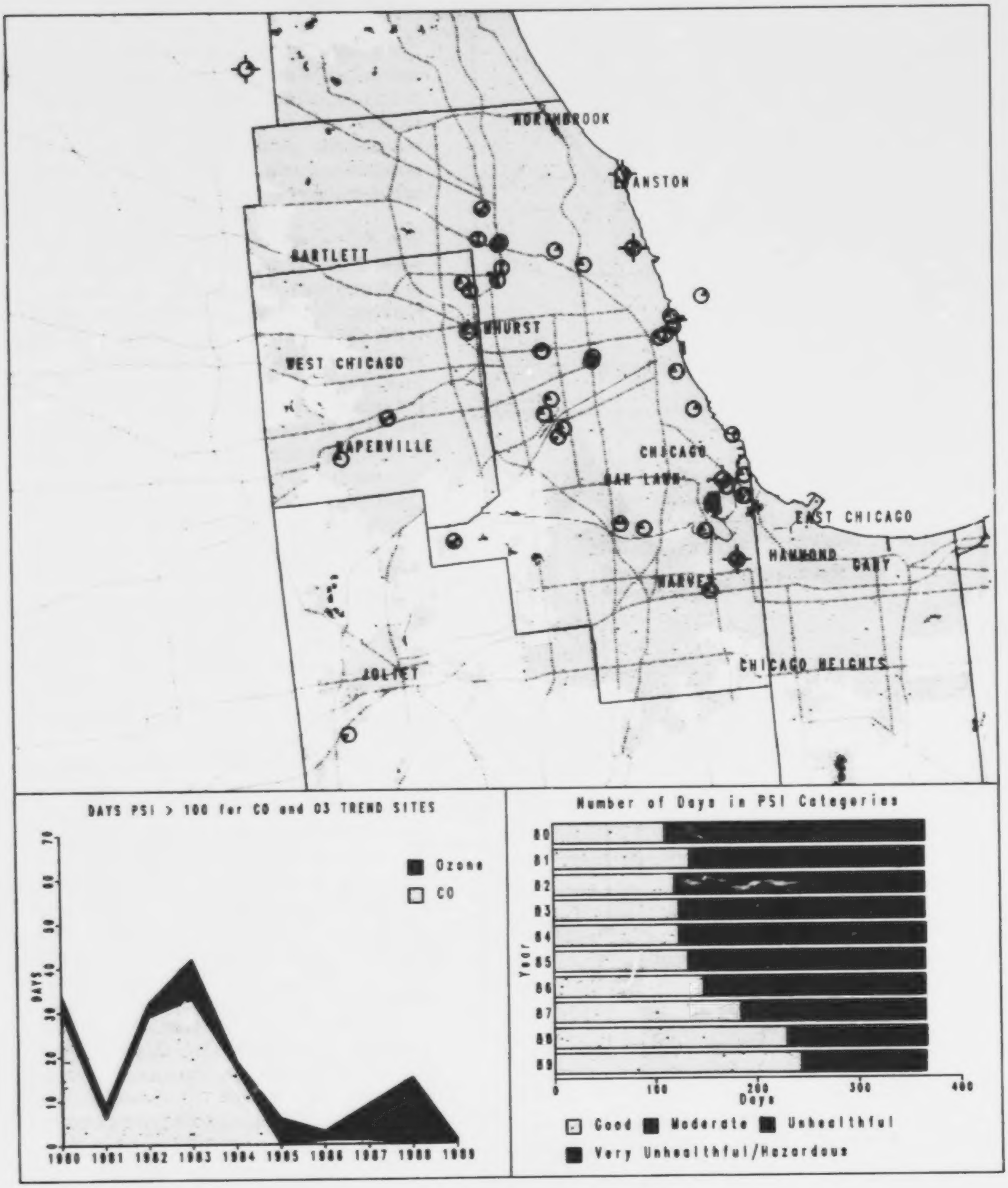


Boston, MA

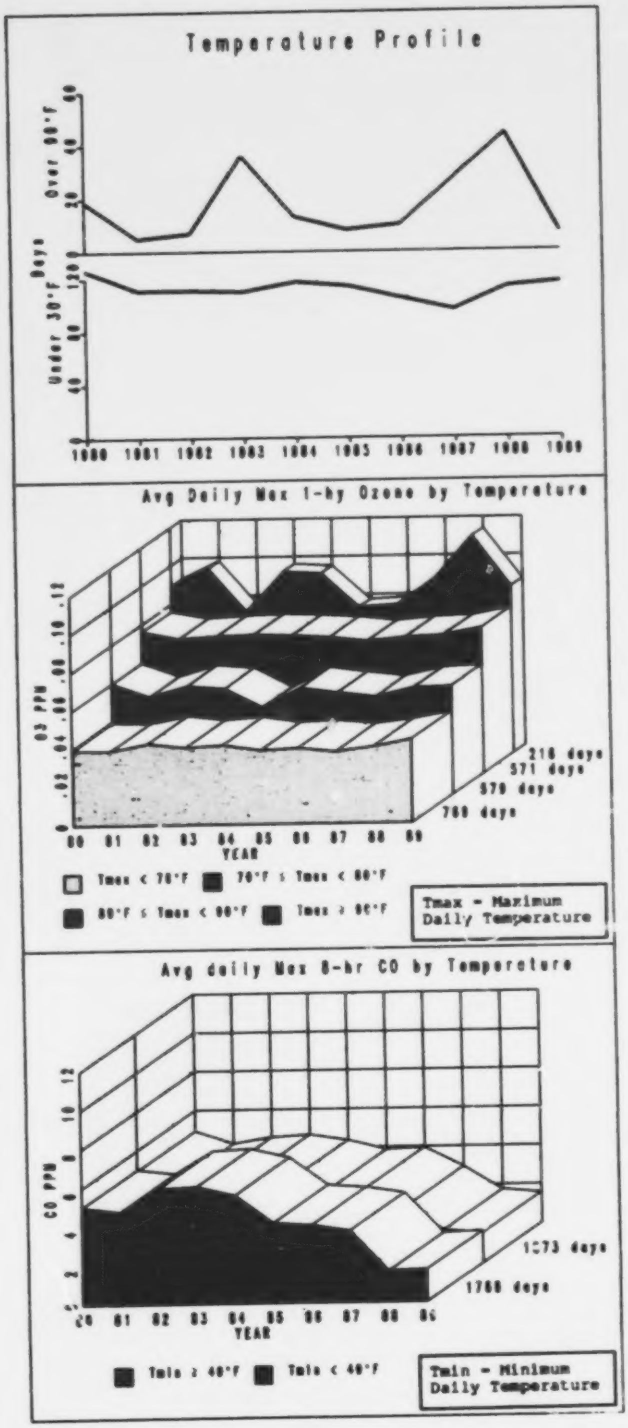
The Boston PMSA consists of Suffolk County and parts of 6 other counties. The estimated 1988 population was 2.8 million. Its size and location as a part of the eastern seaboard megalopolis contribute to the area's air pollution potential. There are 20 currently active monitoring sites located on the map.

The PSI trend for Boston is based on 3 sites: 2 for CO and 1 for O_3. The CO sites are a maximum concentration site located at Kenmore Square and a NAMS neighborhood scale site located in east Boston. The O_3 site is a maximum concentration site in Sudbury (Middlesex County). The trend in the number of PSI days > 100 is similar to the trend in the number of days above 90°, shown in the temperature profile. This can be seen in the PSI bar charts and also in the breakouts for CO and O_3. The impact of the very hot summers of 1983 and 1988 on O_3 levels is evident in both PSI displays. In Boston, 77 percent of the unhealthful or very unhealthful PSI days are due to O_3. In 1989 there was one day with a PSI value above 100. There were 7 days above 90° for this year as compared with 25 in 1988. In the entire 10-year period, only 1 day (in 1983) had a value in the very unhealthful range.

The average CO and O_3 concentrations by temperature follow the expected pattern: O_3 levels are highest on the hotter days and CO levels are slightly higher on the colder days. The O_3 trends in the two highest temperature categories resemble the PSI trends with concentrations generally highest in 1983 and 1988. The exception is for 90° days when the third highest average occurred in 1985 and not 1983. The 1985 average was inflated due to 1 very high O_3 day out of only 4 days reported for this year. In contrast 1983 had 30 90° days. The O_3 trend in the two lowest temperature categories is very flat for the decade. Average CO concentrations declined in each temperature category.


NORTHBROOK
EVANSTON
BARTLETT
ELMHURST
WEST CHICAGO
NAPERVILLE
CHICAGO
OAK LAWN
EAST CHICAGO
HAMMOND
GARY
HARVEY
CHICAGO HEIGHTS
JOLIET
DAYS PSI > 100 for CO and O3 TREND SITES
DAYS
0
10
20
30
40
50
60
70
Ozone
CO
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
Number of Days in PSI Categories
Year
80
81
82
83
84
85
86
87
88
89
0
100
200
300
400
Days
Good
Moderate
Unhealthful
Very Unhealthful/Hazardous

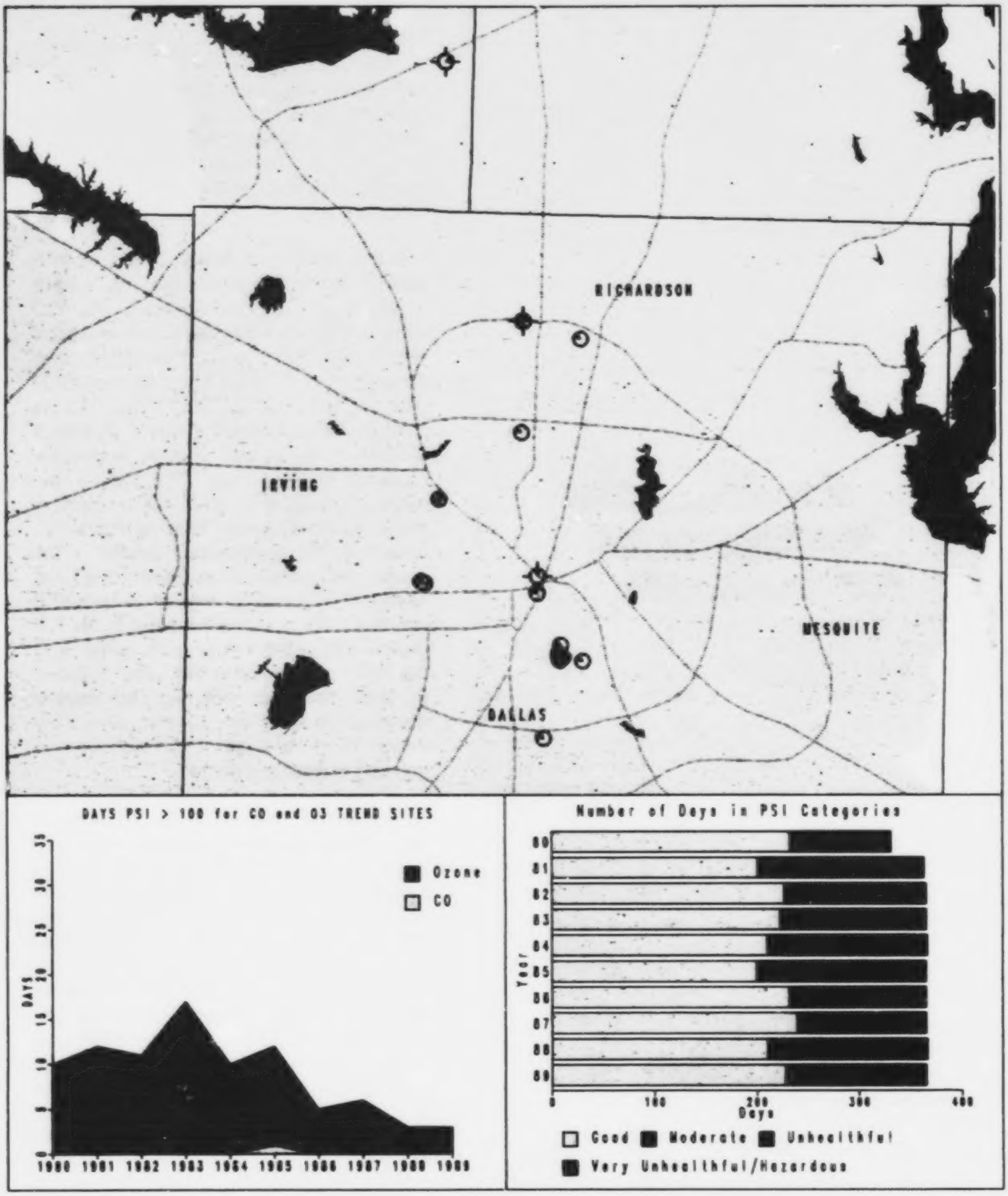
Chicago, IL



The Chicago PMSA consists of Cook, DuPage and McHenry Counties. The estimated 1988 population was 6.2 million with 85% residing in Cook County. Its size and heavy industry contribute to the area's air pollution potential. There are 44 currently active monitoring sites located on the map.

The PSI trend for Chicago is based on 6 sites: 1 site for both CO and O_3, plus 2 other CO and 3 other O_3 sites. The CO sites include a maximum concentration micro-scale site located in downtown Chicago and 2 other population oriented sites in Cook County. The O_3 sites include a maximum concentration site in northwest McHenry County and 3 other population exposure oriented sites. The trend in the number of days with PSI > 100 is similar to the trend in the number of days above 90°, shown in the temperature profile. The impact of the very hot summers of 1983 and 1988 on O_3 levels is evident in both PSI displays. CO accounts for most of the PSI days > 100 in the first 5 years, while O_3 is the main contributor in the latter 5 years. By 1989, there were only two such days in the area. In the entire 10-year period only 3 days (2 in 1988 and 1 in 1982) were in the very unhealthful range.

O_3 levels are highest on the hotter days, while CO levels differ from most cities with lower average CO levels in the coldest temperature category. The O_3 trend in the highest temperature category resembles the PSI trend. The O_3 trend in the 3 lowest temperature categories is very flat over the decade. Average CO concentrations decline in its two temperature categories. However, the CO averages in 1988 and 1989 appear low, because the downtown Chicago site was discontinued in 1987. The percentage decline when all days are considered between 1980 and 1987 was 33 percent.


RICHARDSON
IRVING
MESQUITE
DALLAS

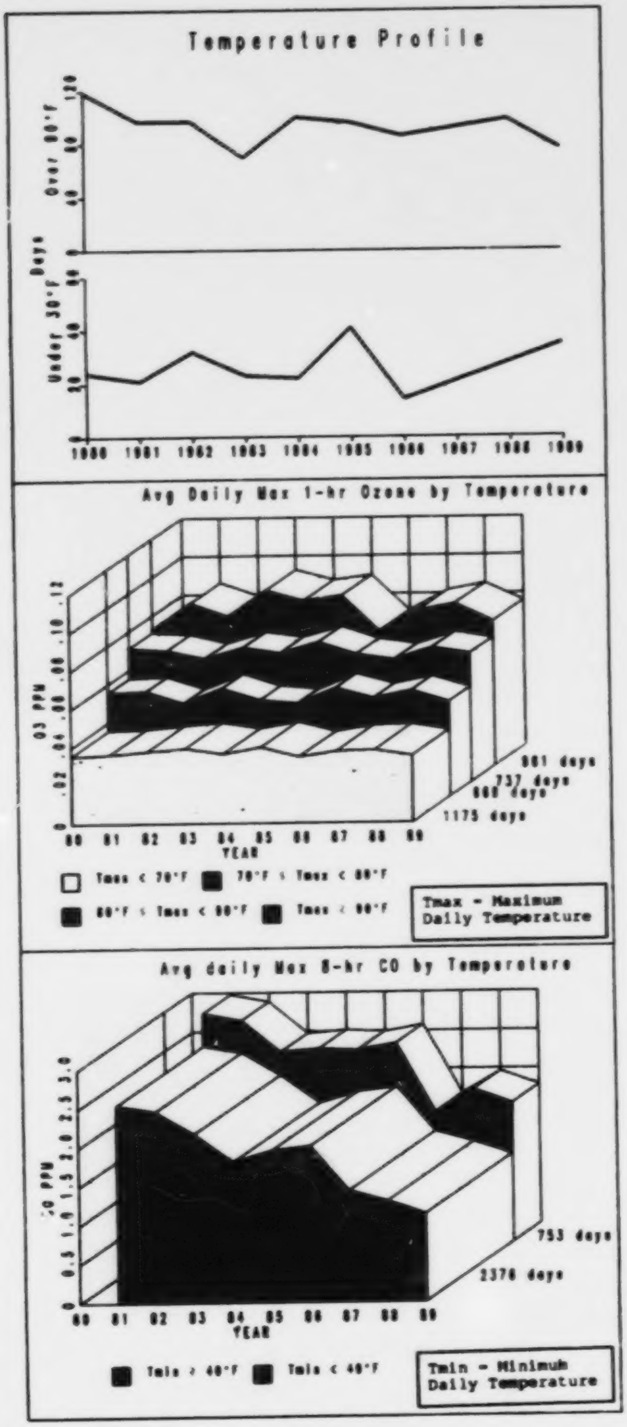
DAYS PSI > 100 for CO and O3 TREND SITES

DAYS
0
5
10
15
20
25
30
35
Ozone
CO
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989

Number of Days in PSI Categories

Year
80
81
82
83
84
85
86
87
88
89
0
100
200
300
400
Days
Good
Moderate
Unhealthful
Very Unhealthful/Hazardous

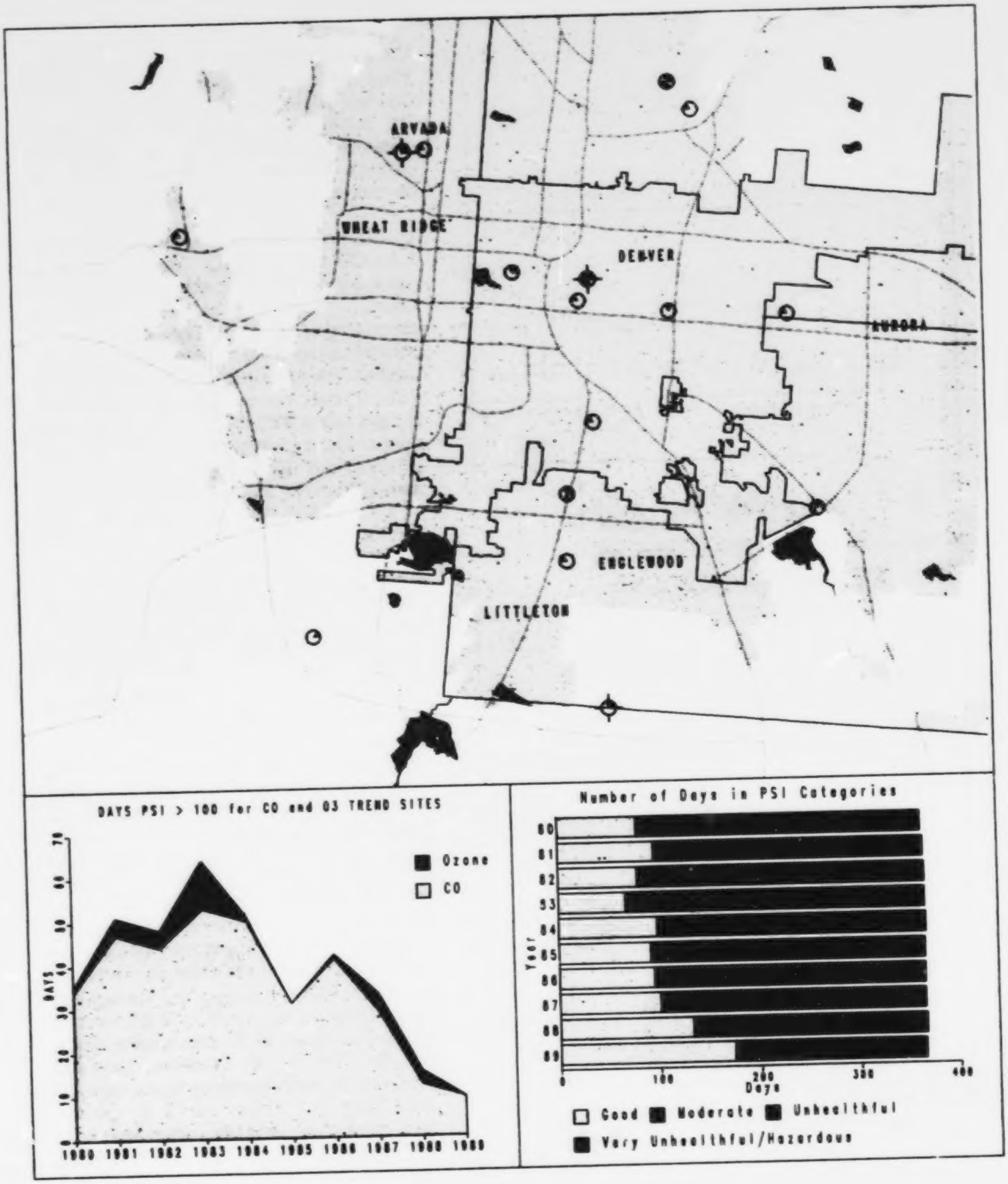
Dallas, TX

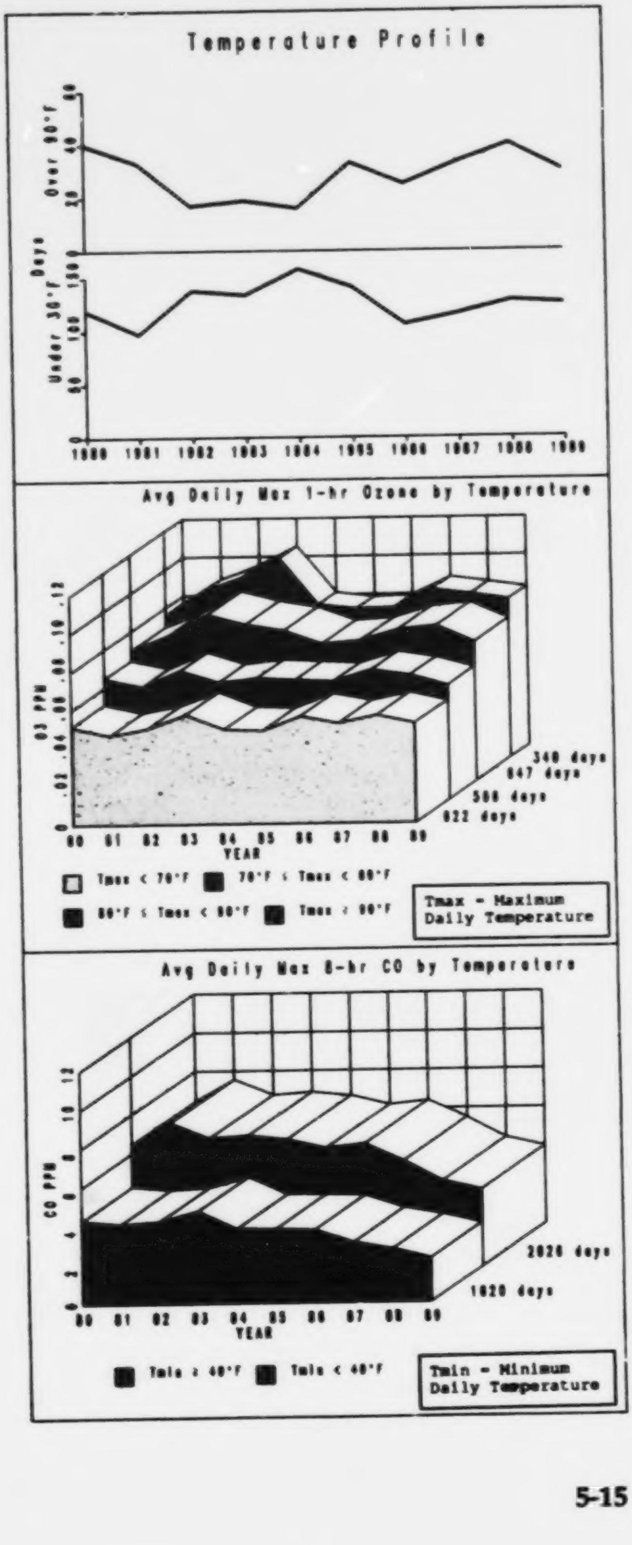


The Dallas PMSA consists of 6 counties with 75 percent of the population residing in Dallas County. The estimated 1988 population was 2.5 million. Its size and summertime meteorology contribute to the area's air pollution potential. The map shows 20 currently active monitoring sites for the area.

The PSI trend for Dallas is based on 3 sites: 1 for CO and 2 for O_3. The CO site is a maximum concentration site located in Dallas County. The O_3 sites are a maximum concentration site in Denton County and a population exposure oriented site in Dallas County. The trend in the number of days with PSI>100 does not correlate with the number of days above 90°, shown in the temperature profile. The highest number of PSI>100 days (17) occurs in 1983, while the number of days above 90° dip for this year. In Dallas all but 1 of the PSI>100 days are due to O_3. The number and percent of PSI>100 days have declined over the decade. This can be seen in both of the PSI plots. In 1989 there were 3 days above a PSI of 100. In the entire 10-year period only 1 day (in 1982) was in the very unhealthful range.

The average CO and O_3 concentrations by temperature follow the expected pattern, i.e. O_3 levels are highest on the hotter days and conversely CO levels are slightly higher on the colder days. Average O_3 concentrations show little net change over the ten years for all temperature categories. The O_3 annual average (0.057 ppm) for all days was exactly the same for 1980 and 1989. The peak in 1983 for PSI>100 days can also be seen in the average O_3 concentration plots; however, average O_3 concentrations level off over the remainder of the decade while, as mentioned earlier, the PSI>100 days drop. Average CO concentrations decline in the two temperature categories. Note that CO data is not available for 1980. For the 1981-89 period, there was a 56 and 40 percent decline in average CO concentrations. There was a 51 percent reduction in annual average CO concentrations when all days are considered.


ARVADA
WHEAT RIDGE
DENVER
AURORA
ENGLEWOOD
LITTLETON
DAYS PSI > 100 for CO and O3 TREND SITES
Ozone
CO
DAYS
0
10
20
30
40
50
60
70
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
Number of Days in PSI Categories
Year
80
81
82
83
84
85
86
87
88
89
0
100
200
300
400
Days
Good
Moderate
Unhealthful
Very Unhealthful/Hazardous

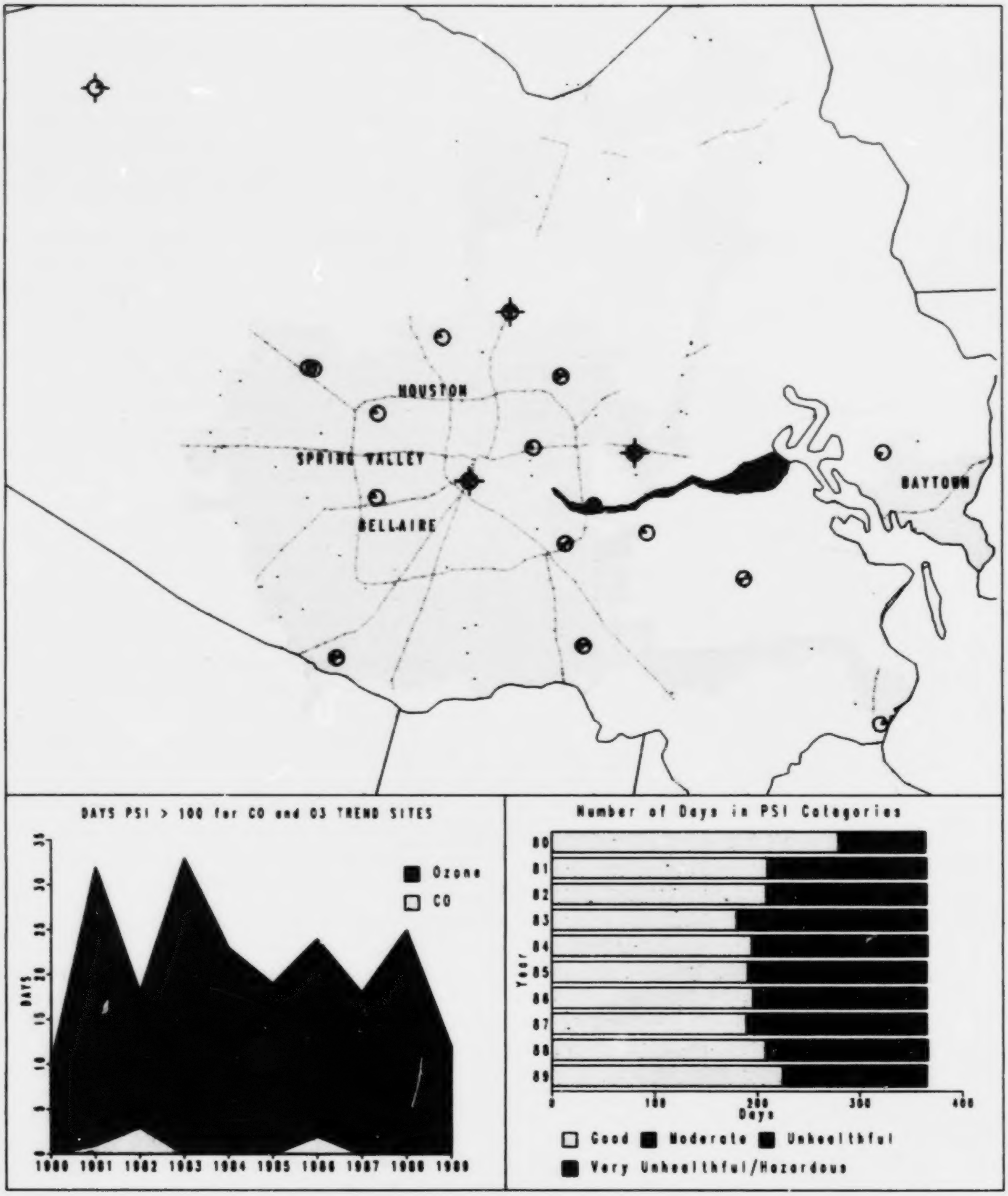


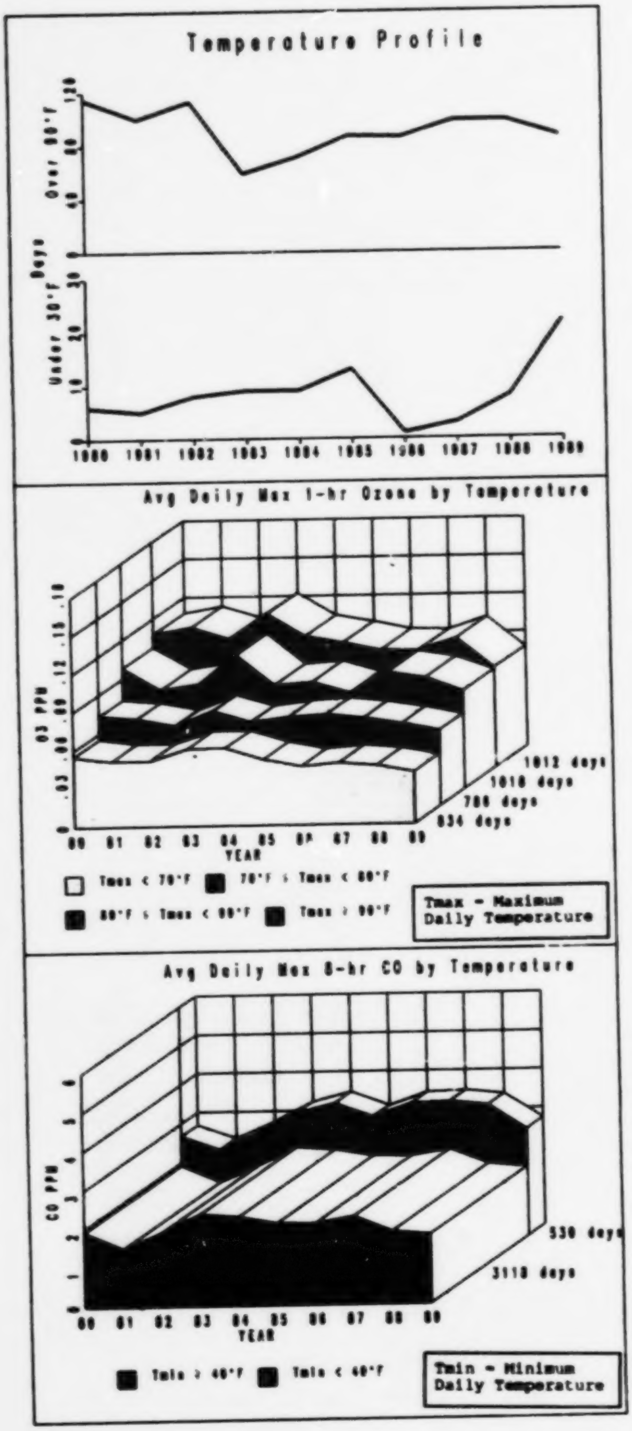
Denver, CO

The Denver PMSA consists of 5 counties, the most populated of which is Denver which has 30 percent of the area's 1.6 million residents estimated for 1988. The area's size and altitude contribute to its air pollution potential. Seventeen monitoring sites are currently active and are shown on the area map.

The PSI trend for Denver is based on 3 sites: 2 where both CO and O_3 are monitored plus 1 other CO site. The CO sites are a maximum concentration site located in downtown Denver and 2 other population oriented sites in Arapahoe and Jefferson Counties. The O_3 sites are maximum concentration sites in Arapahoe Co. and a population exposure site in Jefferson Co. The trend in the number of PSI days > 100 does not fluctuate with either the number of days above 90° or below 30°, as shown in the temperature profile. The figures reveal a reduction in these unhealthful and very unhealthful days. Overall, the lowest number of unhealthful days (10) occurred in 1989. The peak (64) occurs in 1983. For the first time in 1989, there were no very unhealthful days reported at these sites. Three days in the 10-year period were judged to be hazardous, the last occurring in 1985. Accordingly, the number of days classified as good more than doubled from 79 in 1980 to 174 in 1989. In Denver, 92 percent of the PSI days >100 were due to CO. Clearly, the improvement in these days is attributable to CO reductions. These CO days declined from a peak of 53 in 1983 to 9 in 1989.

O_3 levels are highest on the hotter days and CO levels are higher on the colder days. The O_3 trend in all temperature categories peak in 1982 or 1983 and again in 1987 or 1988. Overall, average O_3 levels have not changed much over the 10 years. On the other hand, CO concentrations declined 41 percent overall and declined in each temperature category. The percent change over the decade were, respectively, 47 and 38 percent for the $\geq$ 40° and < 40° temperature categories.


HOUSTON
SPRING VALLEY
BELLAIRE
BAYTOWN
DAYS PSI > 100 for CO and O3 TREND SITES
DAYS
0
5
10
15
20
25
30
35
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
Ozone
CO
Number of Days in PSI Categories
Year
80
81
82
83
84
85
86
87
88
89
0
100
200
300
400
Days
Good
Moderate
Unhealthful
Very Unhealthful/Hazardous

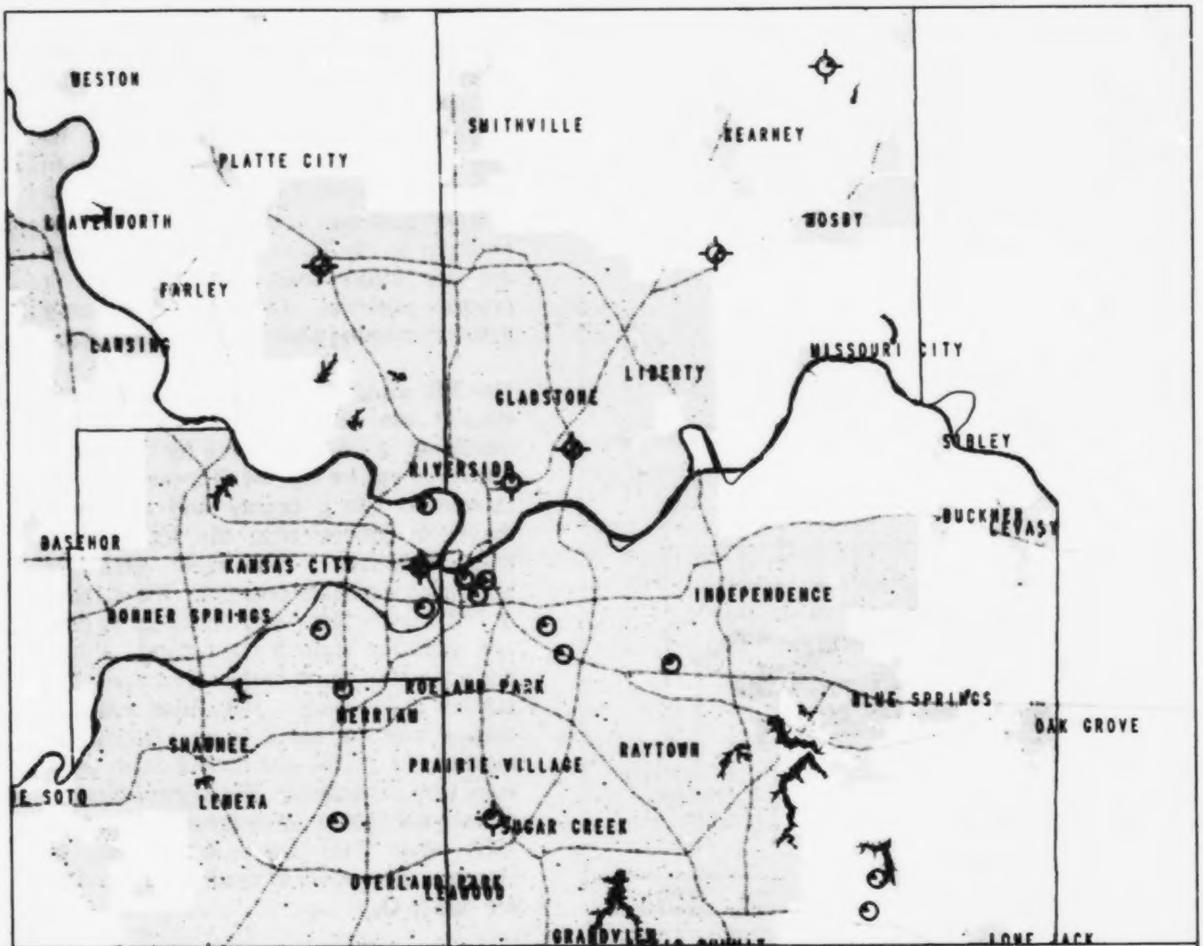


Houston, TX

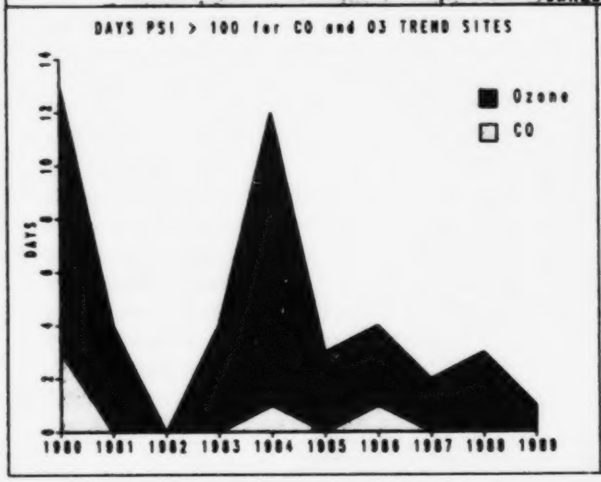
The Houston PMSA consists of the principal county of Harris and 4 other counties. The estimated 1988 population was 3.2 million with 86 percent residing in Harris county. Its size and industry, mainly petroleum refineries, contribute to the area's air pollution potential. Its high temperatures and proximity to the Texas City-Galveston area are also factors which contribute to it's air pollution potential. There are 19 currently active monitoring sites located on the map.

The PSI trend for Houston is based on 4 sites: 1 site where both CO and O_3 are monitored, 2 additional sites for CO and 1 additional site for O_3. All of these sites are located in Harris county and include a maximum concentration site for each of these pollutants. The other sites are population exposure oriented. The number of PSI days > 100 varies from year to year and does not show a clear trend. When additional sites are considered, however, the number of PSI days > 100 shows a steady decline over the last 3 years. During the eighties, 21 (10%) out of 216 such days were very unhealthful. The highest number of very unhealthful days (seven) occurs in 1981, while 1989 only recorded two. In Houston, 96 percent of the PSI days > 100 are due to O_3.

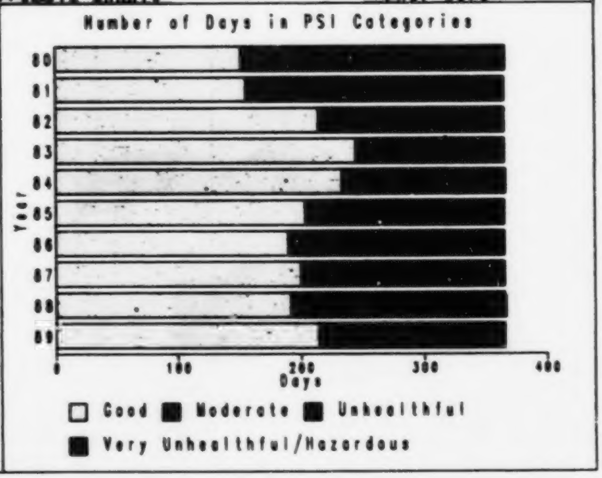
The average CO and O_3 concentrations by temperature follow the expected pattern, with O_3 levels highest on the hotter days and CO levels slightly higher on the colder days. In general, average ozone levels are highest in 1983 and lowest in 1987 across all temperature categories. Average O_3 levels show a slight decline over the decade with a large reduction in 1989. Average CO levels peak in 1983 or 1984 for both temperature categories, then drop 25 and 21 percent for the warmer and colder days. When all days are considered, annual average daily max 8-hour CO was essentially the same in 1980 and 1989. Note that average CO levels are very low in Houston.


WESTON
SMITHVILLE
KEARNEY
PLATTE CITY
LEAVENWORTH
MOSBY
FARLEY
LANSING
MISSOURI CITY
LIBERTY
GLADSTONE
SIBLEY
RIVERSIDE
BUCKNER
LEVASY
BASEHOR
KANSAS CITY
INDEPENDENCE
BONNER SPRINGS
ROELAND PARK
MERRIAM
BLUE SPRINGS
OAK GROVE
SHAWNEE
RAYTOWN
PRAIRIE VILLAGE
DE SOTO
LENEXA
SUGAR CREEK
OVERLAND PARK
LEAWOOD
GRANDVIEW
LONE JACK

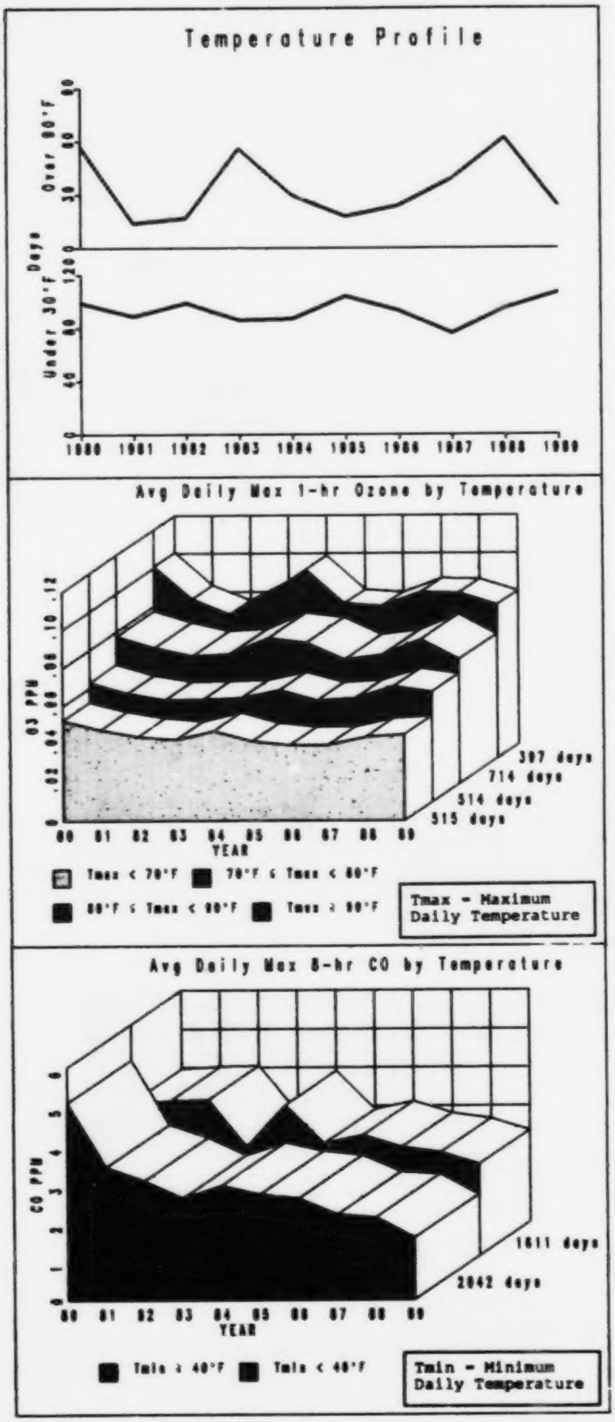
DAYS PSI > 100 for CO and O3 TREND SITES



Number of Days in PSI Categories



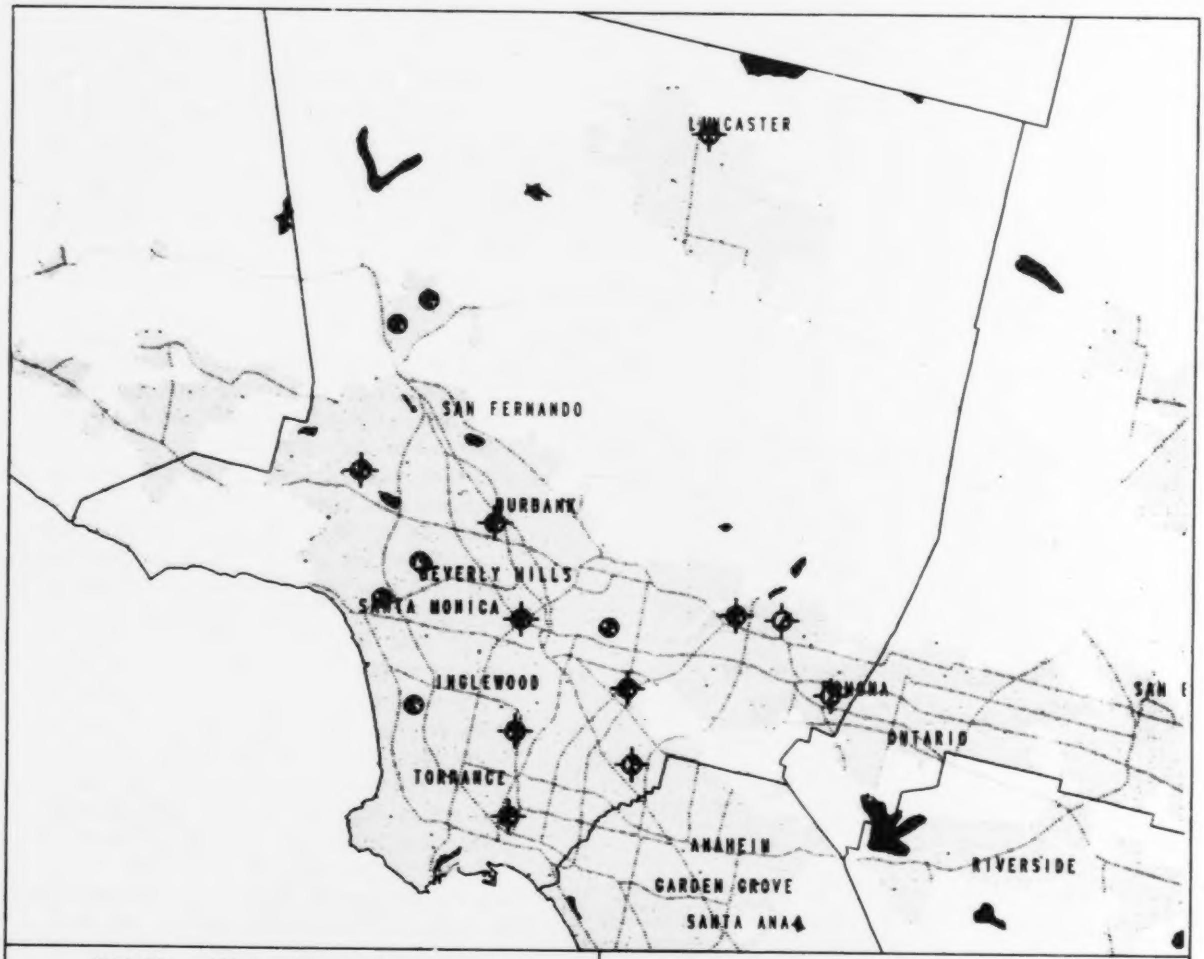
Kansas City, MO-KS

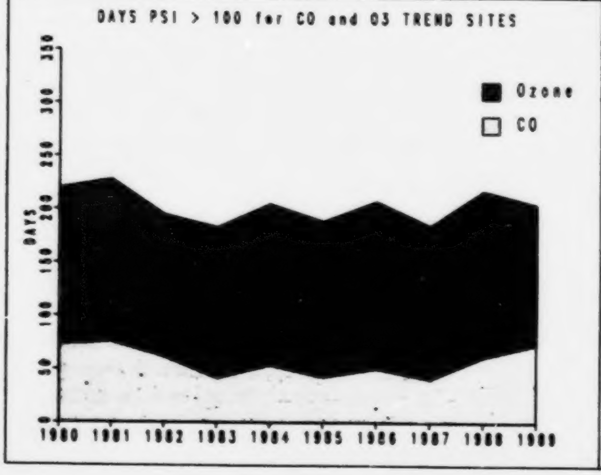


The Kansas City PMSA consists of 6 counties in Missouri and 4 counties in Kansas. The estimated 1988 population was 1.6 million. Its size and summertime meteorology contribute to the area's air pollution potential. Its chief air quality problems occur during the summer when the hot, stagnant days are conducive to O_3 formation. The map shows 21 currently active monitoring sites in this PMSA.

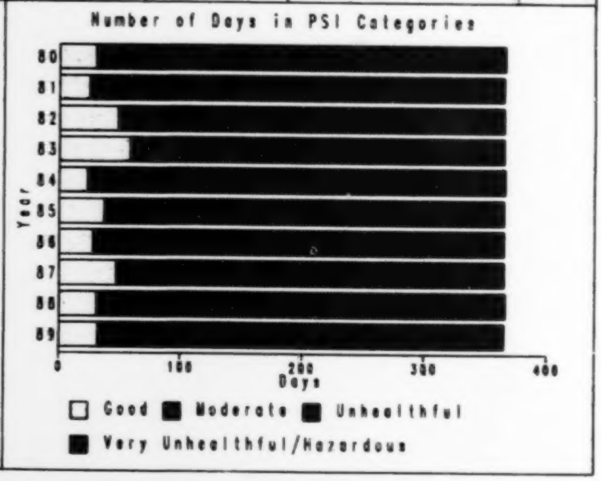
The PSI trend for Kansas City is based on 7 monitoring sites: 1 site where both CO and O_3 are monitored plus 2 other CO and 4 other O_3 sites. The CO sites are all population exposure oriented, while the O_3 sites include 1 maximum concentration site and 4 population exposure sites. The trend in the number of days with PSI > 100 does not relate well with the pattern of the number of days above 90°. This is especially true for 1983, 1984 and 1988. The absence of stronger 1983 and 1988 peaks in the number of PSI > 100 days is surprising, since in both of these years the summers were very hot. There were 18 and 16 days in 1983 and 1988 respectively when a temperature of 100 or above was recorded. Even though in 1984 there were only 4 days with temperatures in the 100 range, this year had the second highest number of sites (3) exceeding the NAAQS. However, 1984 had several multi-day episodes of exceedances. The number of days with an unhealthful or worse rating varies from a low of 0 days in 1982 to 13 days in 1980. In 1989, 1 day was judged to be unhealthful. In the 10-year period there were no days in the very unhealthful or worse ranges.

Average CO and O_3 concentrations by temperature category follow the expected pattern: O_3 levels are highest on the hotter days and CO levels are generally higher on colder days. Average CO concentrations have dropped in both temperature classes. The trend in average O_3 levels is fairly stable, excluding the 1980 and 1984 peaks for all temperature categories.


LANCASTER
SAN FERNANDO
BURBANK
BEVERLY HILLS
SANTA MONICA
INGLEWOOD
POMONA
SAN
ONTARIO
TORRANCE
ANAHEIM
GARDEN GROVE
SANTA ANA
RIVERSIDE

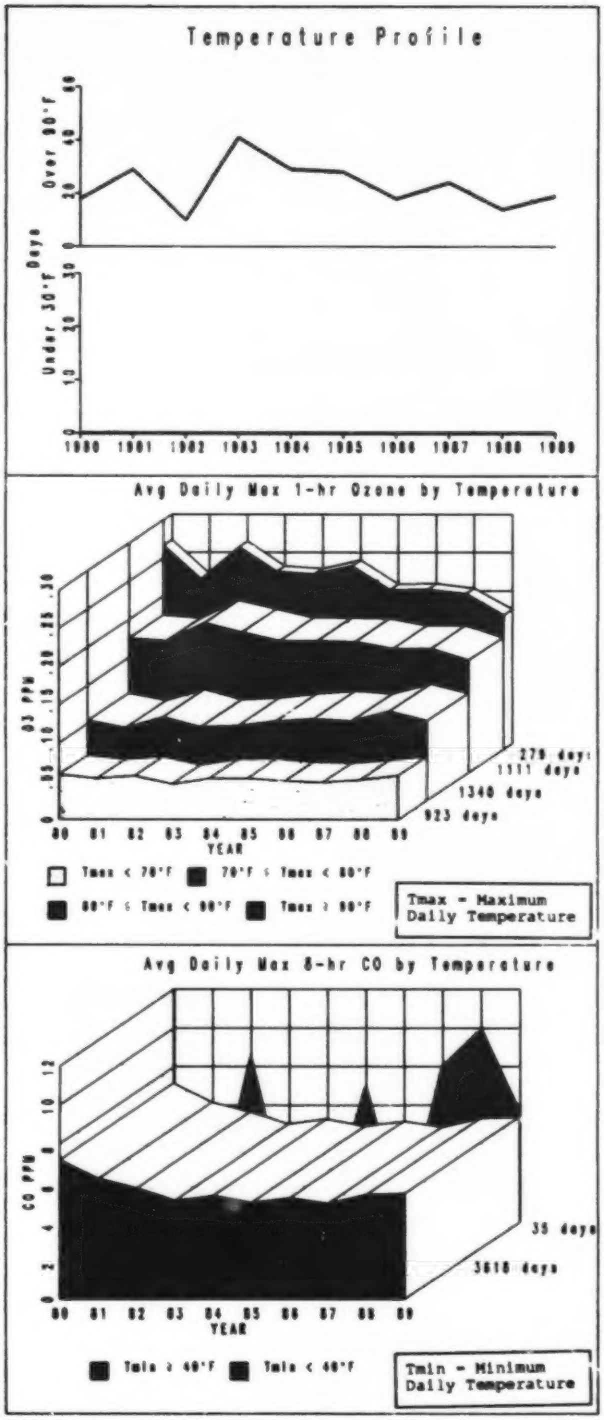


DAYS PSI > 100 for CO and O3 TREND SITES



Number of Days in PSI Categories

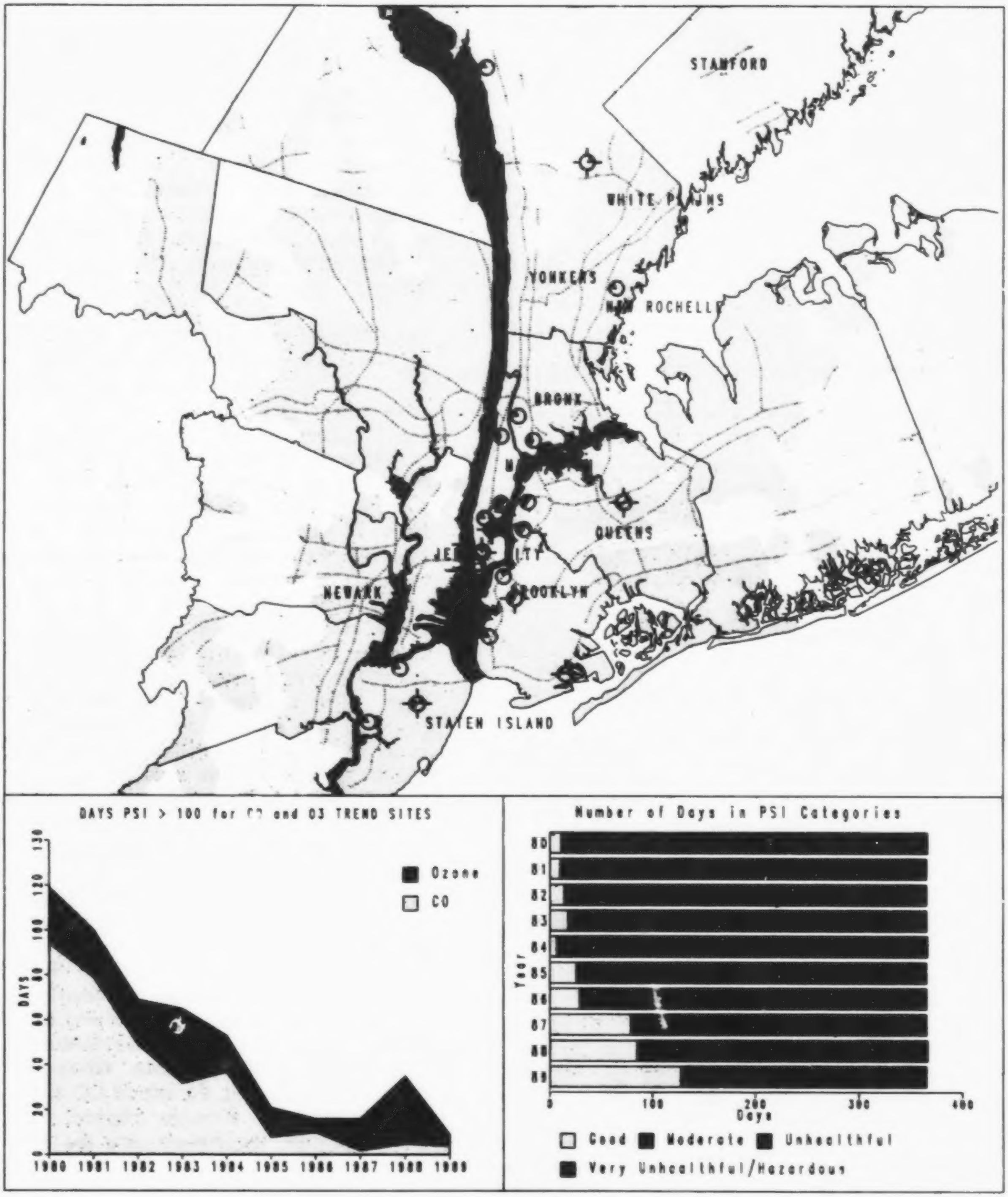
Los Angeles, CA



The LA PMSA consists of Los Angeles County, where an estimated 8.5 million people resided in 1988. The LA "basin" is bounded by the Pacific ocean on the west and south and several mountain ranges on the north and east. Its complex meteorology is characterized by a land-sea-breeze circulation, frequent inversions, and a high incidence of sunlight. There are 18 currently active monitoring sites located on the map.

The PSI trend for LA is based on 11 sites: 10 where both CO and O_3 are monitored plus 1 other O_3 site. For each pollutant, there is a NAMS maximum concentration site; the others are all population oriented SLAMS sites. LA has the largest number of PSI days > 100 of any urban area - averaging 204 per year for the decade. The trend in these days is essentially flat, however, there has been a 48 percent reduction in the very unhealthful days as shown in the PSI bar charts. Conversely, the number of days in the unhealthful category increased 41 percent because of the shift from very unhealthful to unhealthful days. The number of good days has remained fairly constant during the 1980's. In LA, 72 percent of the PSI days > 100 are due to O_3. In 1989, there were 206 days in the unhealthful or worse categories. In the 10-year period, only 4 days (3 in 1980 and 1 in 1982) were in the hazardous category.

The average CO and O_3 concentrations by temperature did not follow the expected pattern because there are so few days in some of the temperature categories. For example, for O_3 there were only 57 days for the 10-year period with corresponding air quality data in the highest temperature category using LAX airport data. When all days were considered, the annual CO and O_3 daily maximum averages dropped, 15 and 25 percent, respectively, over the 10 years.


STAMFORD
WHITE PLAINS
YONKERS
NEW ROCHELLE
BRONX
M
QUEENS
JE ITY
NEWARK
BROOKLYN
STATEN ISLAND
DAYS PSI > 100 for CO and O3 TREND SITES
DAYS
0
20
40
60
80
100
120
130
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
Ozone
CO
Number of Days in PSI Categories
Year
80
81
82
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Days
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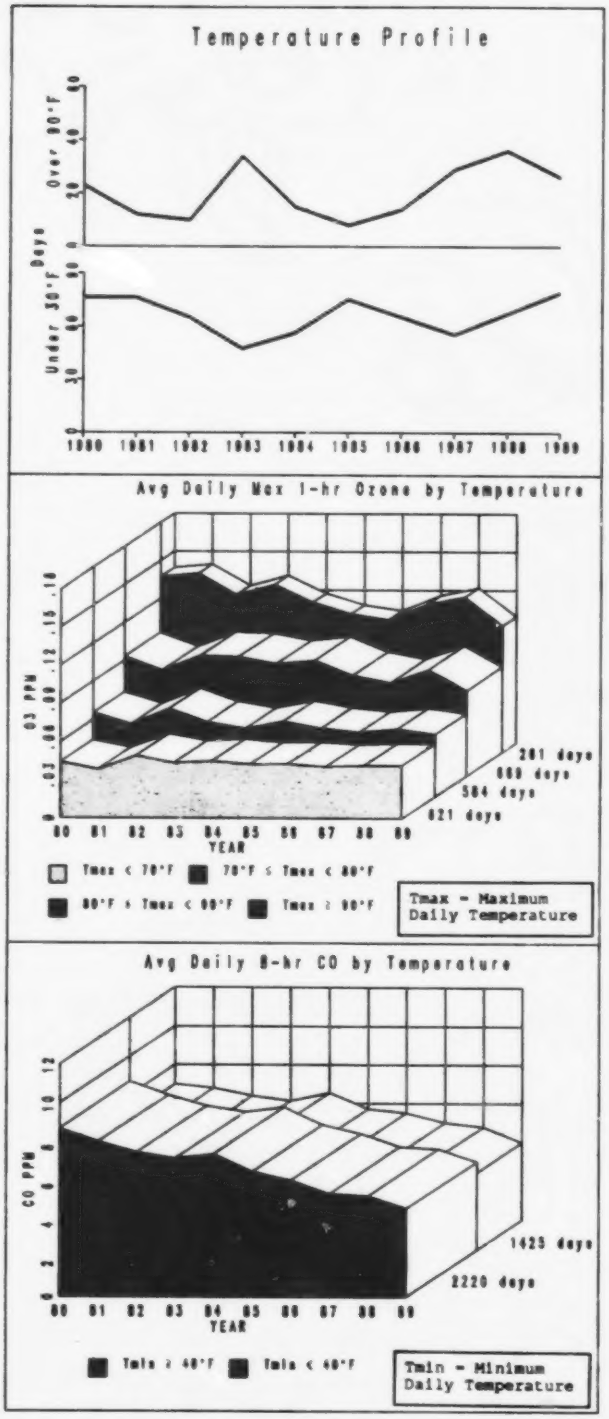
Moderate
Unhealthful
Very Unhealthful/Hazardous

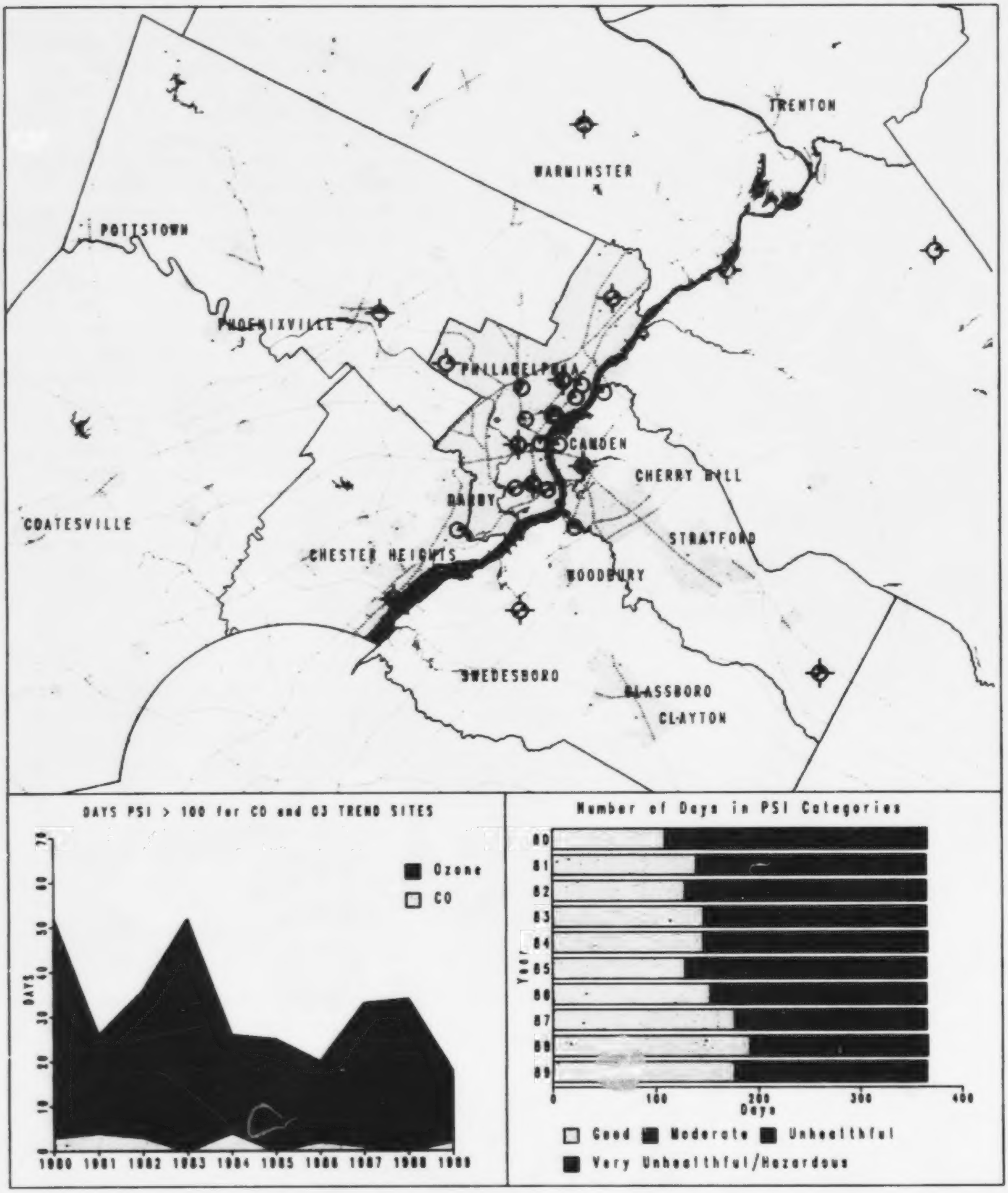


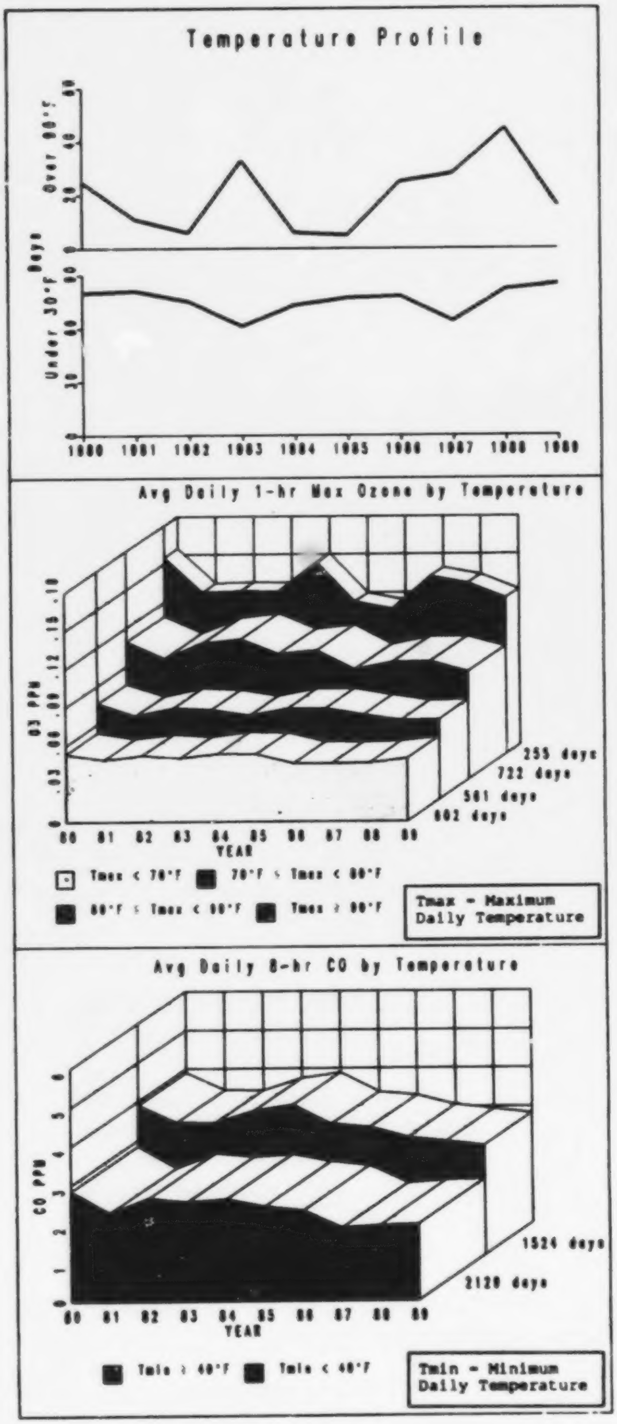
New York, NY

The New York PMSA consists of 8 counties with 81 percent of the population residing in Bronx, Kings, New York, and Queens Counties. The estimated 1988 population was 8.6 million. Its size and location as a part of the eastern seaboard megalopolis contribute to the area's air pollution potential. Twenty-four currently active monitoring sites are shown on the map.

The PSI trend for New York is based on data from 8 sites: 3 for CO and 5 for O_3. The CO sites are 2 maximum concentration sites located in Manhattan (New York County) and a population exposure site in Kings County. The O_3 sites include a maximum concentration site in Westchester County. PSI days > 100 are dominated by CO and do not fluctuate with the number of days above 90°. However, in 1983 and 1988 the impact of the very hot summers is seen with the increase in the days due to O_3. The total number of these days declined from 119 in 1980 to 9 days in 1989. The most dramatic improvement has been in CO where the number of these days declined from 94 in 1980 to 4 in 1989. There was a total of 11 very unhealthful days reported, including 1 each in 1987 and 1988 and none in 1989. Also, there was an improvement in the number of good days - from 11 in 1980 to 128 days in 1989.

O_3 levels are highest on the hotter days. Ozone averages in most of the temperature categories show the impact of the 1983 and 1988 summers. Average O_3 levels for all days during the O_3 season have dropped 23 percent over the decade with most of this drop occurring from 1988 to 1989. The 1989 O_3 average was the lowest for the entire period. New York City CO levels do not show the usual seasonal pattern of low summertime values. Average CO levels in the $\geq$40° category are higher than in the <40° category. The annual CO average, when all days are considered, decreased 40 percent over the period.


TRENTON
WARMINSTER
POTTSTOWN
PHOENIXVILLE
PHILADELPHIA
CAMDEN
CHERRY HILL
DARBY
COATESVILLE
STRATFORD
CHESTER HEIGHTS
WOODBURY
SWEDESBORO
GLASSBORO
CLAYTON
DAYS PSI > 100 for CO and O3 TREND SITES
Ozone
CO
DAYS
0
10
20
30
40
50
60
70
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
Number of Days in PSI Categories
Year
80
81
82
83
84
85
86
87
88
89
0
100
200
300
400
Days
Good
Moderate
Unhealthful
Very Unhealthful/Hazardous

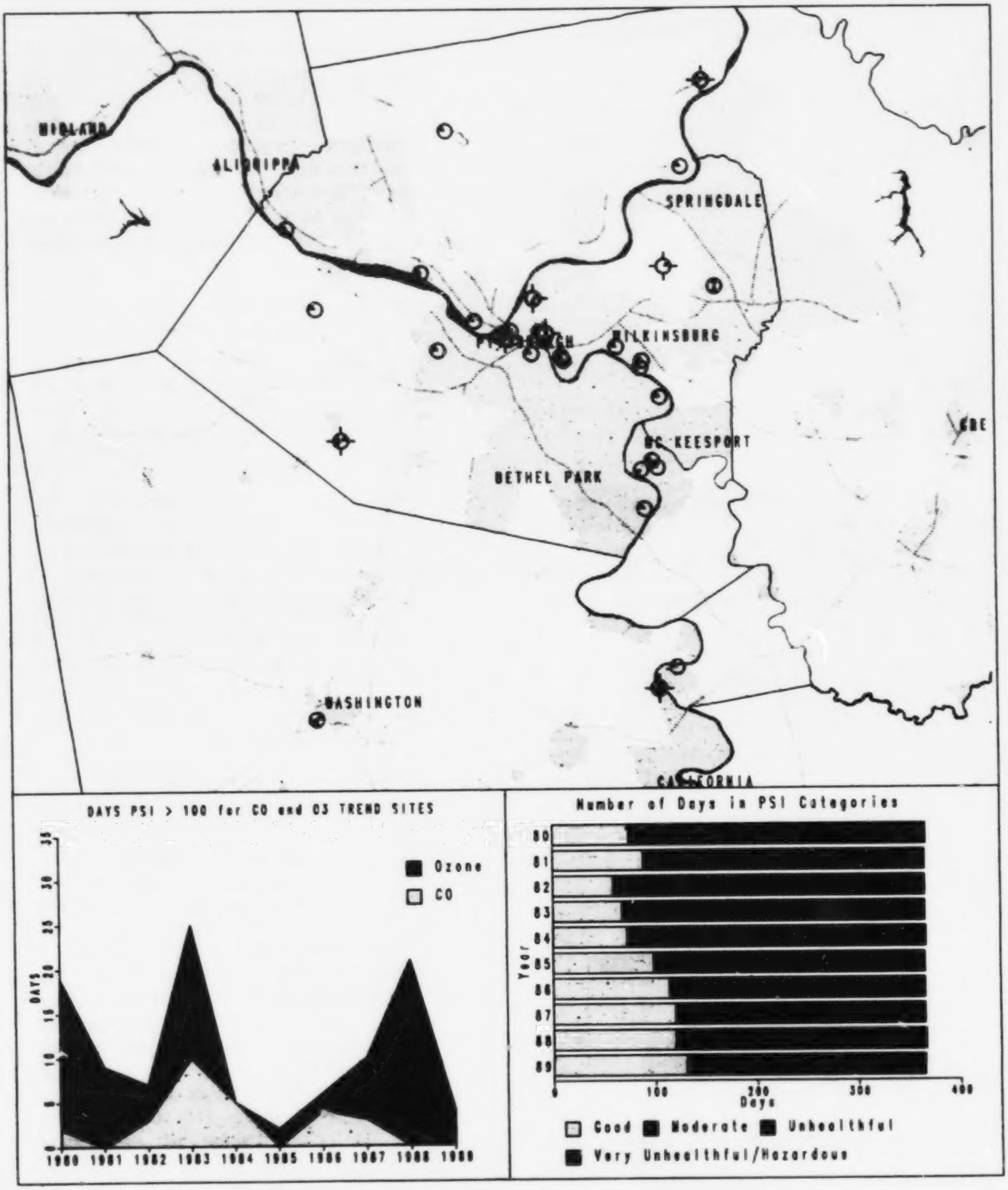


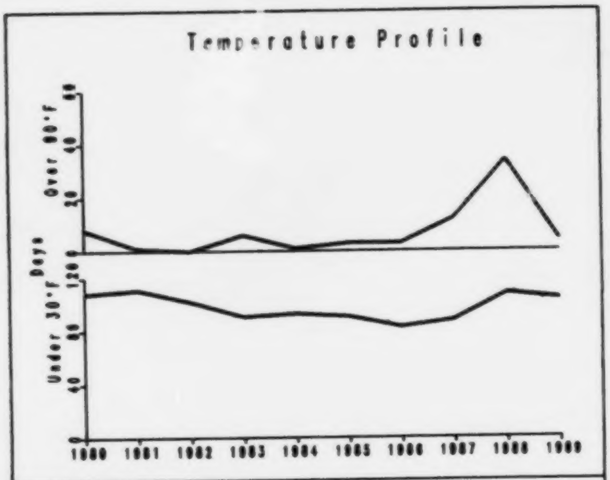
Philadelphia, PA

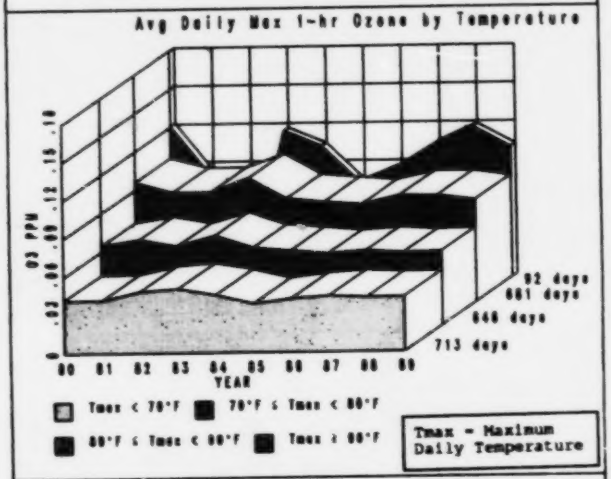
The Philadelphia PMSA consists of 8 counties, 5 in PA and 3 in NJ. The most populated County is Philadelphia which accounts for 33 percent of the total population. The estimated 1988 population was 4.9 million. Its size and location as a part of the eastern megalopolis contribute to the area's air pollution potential. There are 27 currently active air monitoring sites shown on the map.

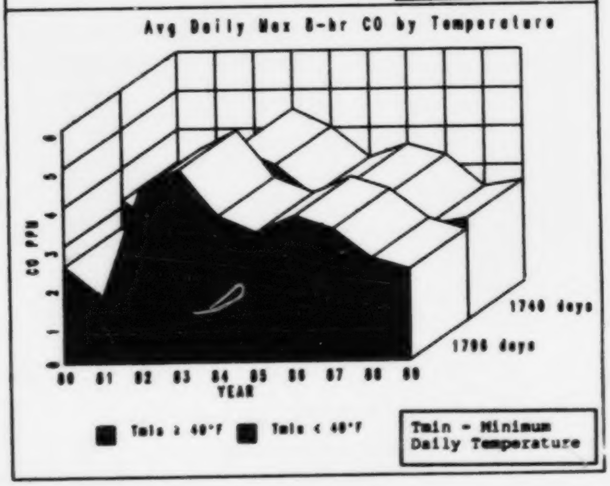
The PSI trend for Philadelphia is based on data from 13 sites: 4 sites where both CO and O_3 are monitored, 4 CO sites, and 5 O_3 sites. The CO sites include a maximum concentration site located in downtown Philadelphia. The O_3 sites also include a maximum concentration site in Gloucester County, NJ. The trend in the PSI days > 100 varies with the number of days above 90°, shown in the temperature profile. The impact of the hot 1983 and 1988 summers on O_3 levels is observed in the PSI displays. In 1987, the number of high PSI days and days above 90° also coincide. Ninety-four percent of the PSI days > 100 are due to O_3. In 1989, there were 18 days in this range. In the 10 years, 14 days were in the very unhealthful range. No days in the hazardous range were reported.

O_3 levels are highest on the hotter days, while CO levels are higher on the colder days. The O_3 trend in the 2 highest temperature categories resemble the PSI trends since levels are generally highest in 1983 and 1988. The principle exception is the 1984 peak in the ≥90° category. This peak is inflated because there were only 7 days represented, one of which was the highest measured O_3 value for the 10-year period. Considering all days, average daily maximum O_3 levels decreased 21 percent between 1980 and 1989. Annual average daily max 8-hour CO levels declined in both temperature categories. This 10-year decline was 19 percent when all days were considered.


MIDLAND
ALIQUIPPA
SPRINGDALE
PITTSBURGH
WILKINSBURG
McKEESPORT
BETHEL PARK
GRE
WASHINGTON
CALIFORNIA
DAYS PSI > 100 for CO and O3 TREND SITES
DAYS
0
5
10
15
20
25
30
35
Ozone
CO
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
Number of Days in PSI Categories
Year
80
81
82
83
84
85
86
87
88
89
0
100
200
300
400
Days
Good
Moderate
Unhealthful
Very Unhealthful/Hazardous





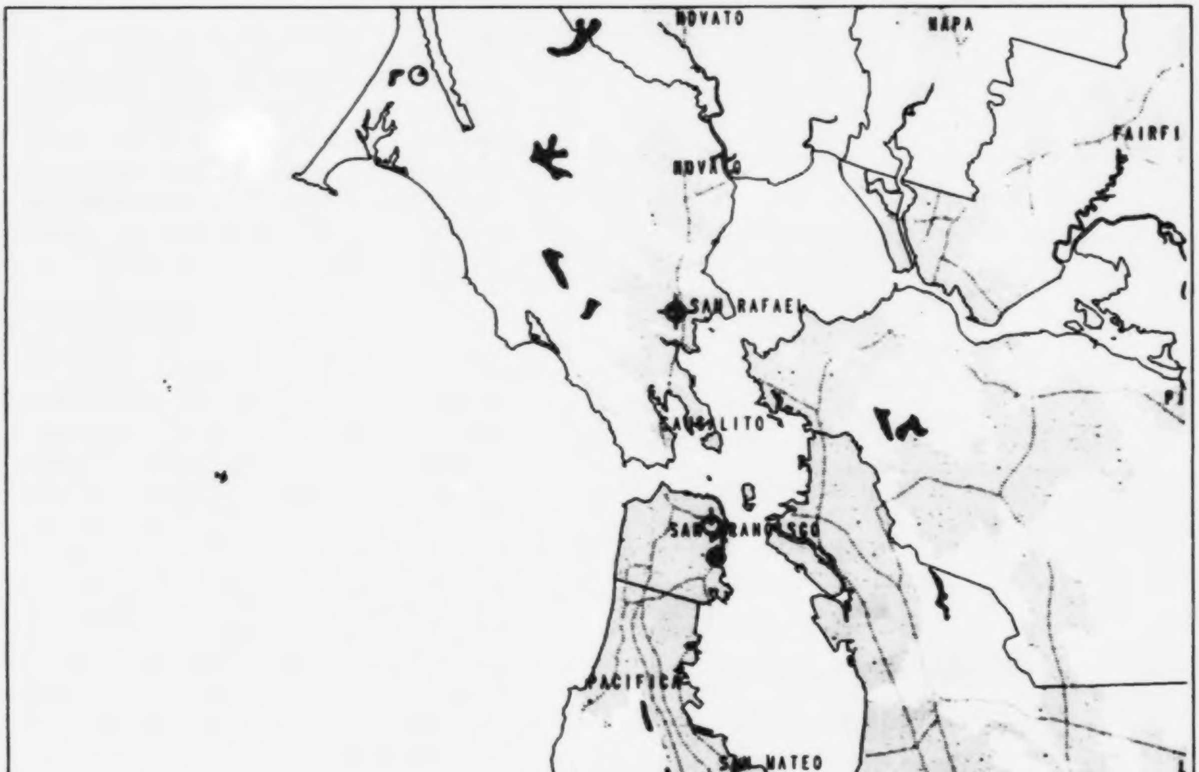


Pittsburgh, PA

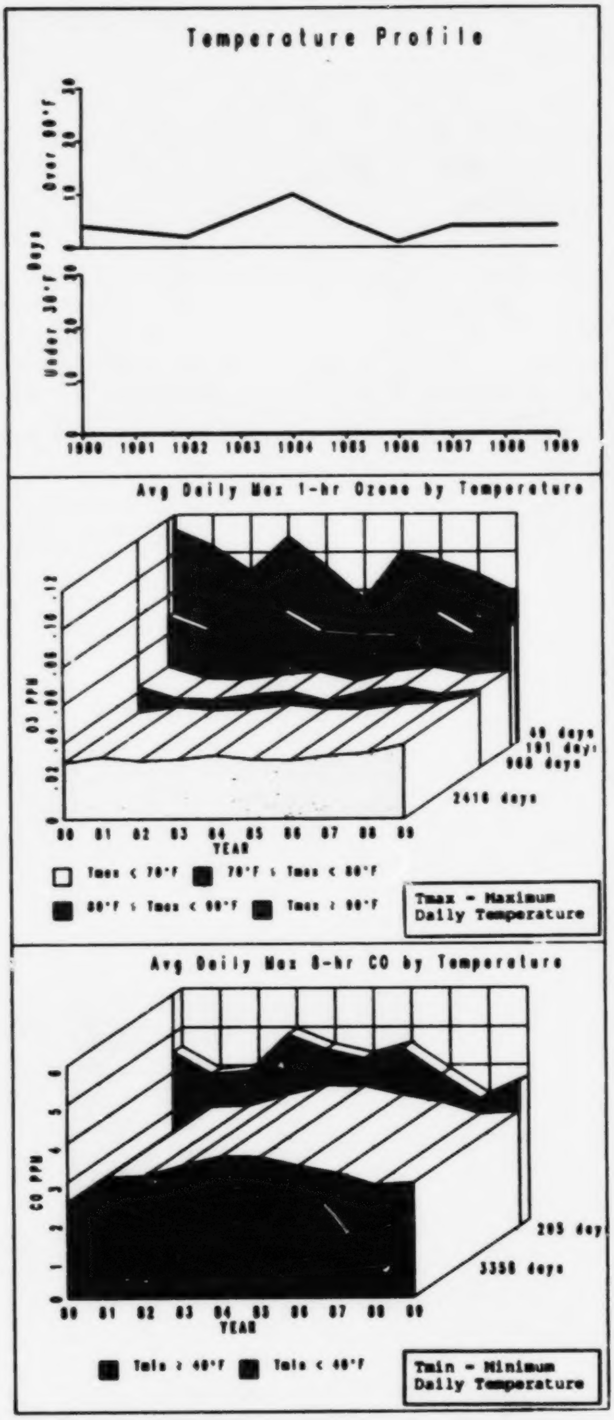
The Pittsburgh PMSA consists of 4 counties, with 65 percent of the population residing in Allegheny County. The estimated 1988 population for the entire area was 2.1 million. Its size and heavy industry contribute to the area's air pollution potential. There are 32 currently active monitoring sites shown on the map.

The PSI trend is principally based on data from 7 sites: 2 CO, and 5 O_3. Each of these pollutants had a NAMS maximum concentration site in Allegheny County. The other sites were all population exposure oriented. SO_2 and PM_{10} data are included in the PSI bar charts only, based on 8 and 20 sites respectively. The trend in the number of O_3 days with PSI > 100 varies with the number of 90° days. The impact of the very hot 1983 and 1988 summers on O_3 is evident in both PSI displays. Forty-four percent of all PSI days > 100 are due to O_3. In fact, SO_2 accounts for 33 percent. The remainder of high PSI days come from CO (15 percent) and PM_{10} (8 percent). In 1989, there were 4 days due to O_3, 1 day for SO_2 and 6 days attributable to PM_{10}. In the 10-year period, 3 days (the last in 1985) fell in the very unhealthful category.

The temperature profile shows that O_3 levels are highest on the hotter days. However, for most years the number of 90° days is small, so that the O_3 averages are variable. The principal exception is 1988, when 38 90° days were recorded. When all days are considered, the O_3 average is down 13 percent from 1980 and CO average concentrations dropped 40 percent from 1983 to 1989. Low CO in 1980 and 1981 are caused by missing data from the max concentration site. Annual average SO_2 levels, not shown here, dropped 24 percent over the 10-year period.


NOVATO
NAPA
FAIRFI
NOVATO
SAN RAFAEL
SAUSALITO
SAN FRANCISCO
PACIFICA
SAN MATEO
MIRAMAR
FREMONT
PALO ALTO
DAYS PSI > 100 for CO and O3 TREND SITES
Ozone
CO
DAYS
0
1
2
3
4
5
6
7
1980 1981 1982 1983 1984 1985 1986 1987 1988 1989
Number of Days in PSI Categories
Year
80
81
82
83
84
85
86
87
88
89
0
100
200
300
400
Days
Good
Moderate
Unhealthful
Very Unhealthful/Hazardous

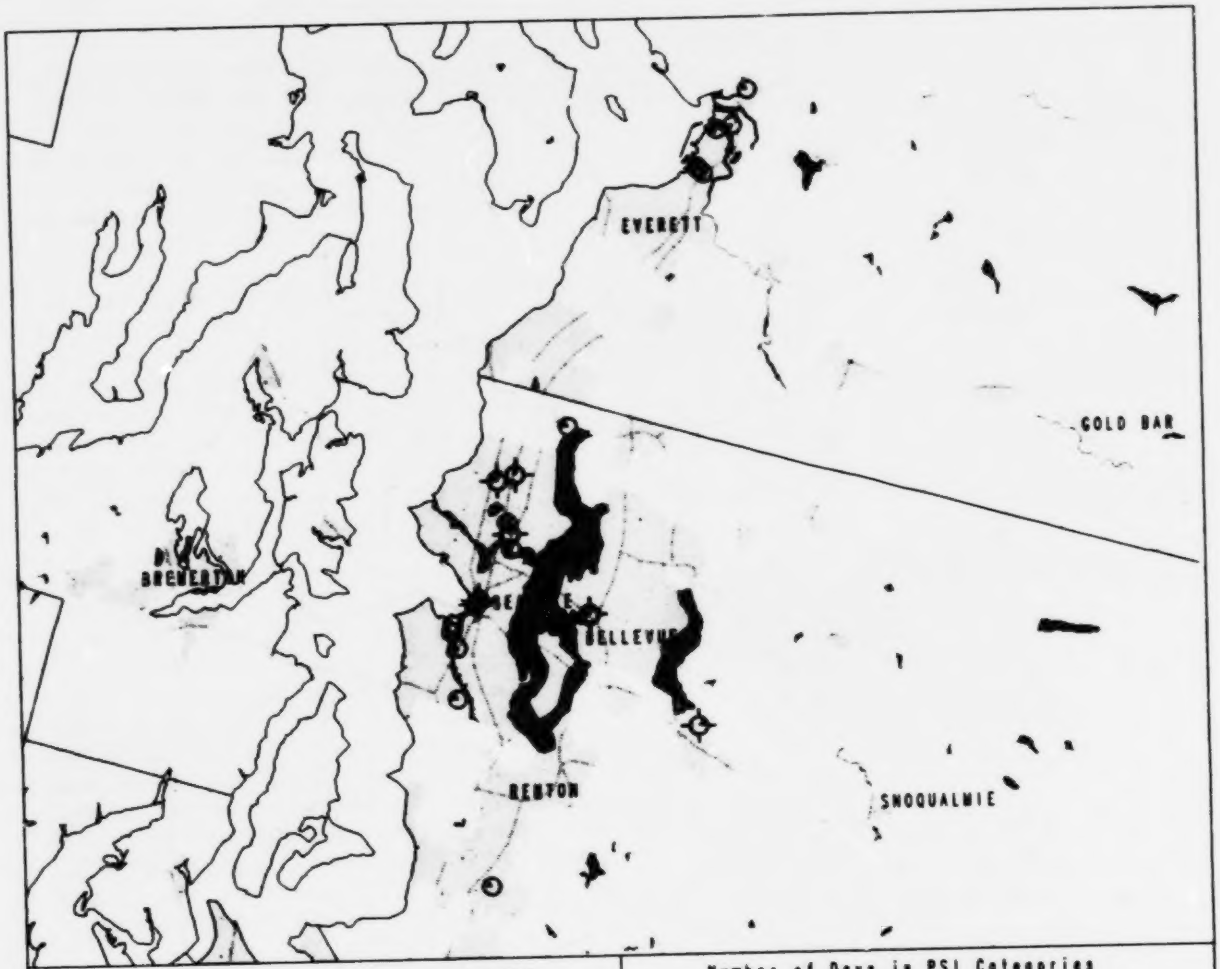
San Francisco, CA



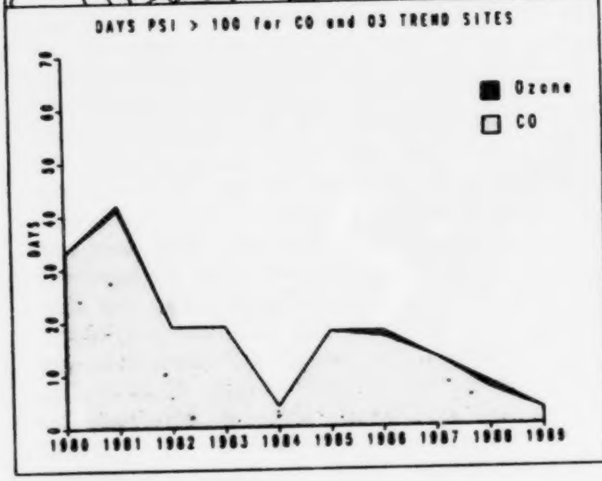
The San Francisco PMSA consists of Marin, San Francisco and San Mateo Counties. The estimated 1988 population was 1.6 million. Its urban area size contributes to the area's air pollution potential. There are 5 currently active monitoring sites located on the map.

The PSI trend for San Francisco is based on 5 monitors (3 for CO and 2 for O_3) at 3 distinct monitoring sites. The CO sites are a NAMS maximum concentration site located in San Francisco County and 2 population exposure sites in Marin and San Mateo Counties. The O_3 data comes from 2 population exposure sites in Marin and San Mateo Counties. The number of PSI days > 100 and unhealthful days average slightly more than 2 days per year. The largest number of these days (5) occurred in 1985. In 1989, for the first time, there were no PSI days > 100 recorded. Over the bay in the Oakland PMSA, the number of PSI days > 100 averages about 7. The largest number of these days (14) occurred in 1983, and like San Francisco, 1989 had the smallest number (2). In Oakland, ozone accounted for all of these days. In San Francisco, 73% of the PSI days > 100 days are due to CO. In the entire 10-year period, only 1 day (in 1985) was in the very unhealthful range.

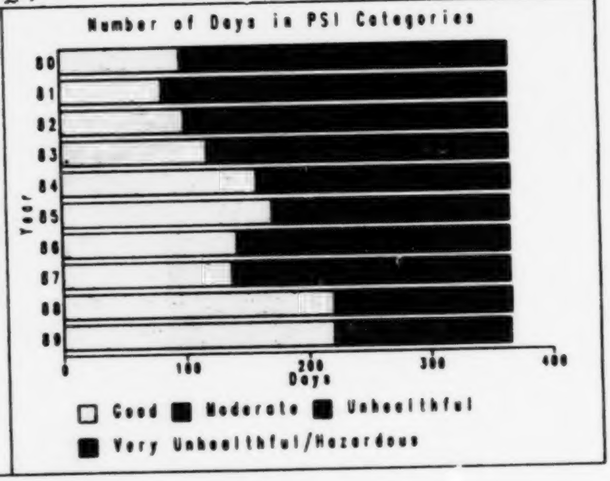
O_3 levels are highest on the hotter days, while CO levels are slightly higher on the colder days. However, the number of high pollution days are small. The average O_3 levels are low in San Francisco when compared with other urban areas. The number of days are low in the < 40° temperature category. The CO annual averages for all days and those days with minimum temperatures > 40° are highest in 1984 and 1985, falling off before and after. This pattern is also observed in Oakland; although the average CO levels there are lower than in San Francisco. When all days are considered, there is essentially no difference in the 1980 and 1989 O_3 annual averages. This is also the case in Oakland.



EVERETT
GOLD BAR
BREMERTON
SEATTLE
BELLEVUE
RENTON
SNOQUALMIE



DAYS PSI > 100 for CO and O3 TREND SITES
Ozone
CO
DAYS
0
10
20
30
40
50
60
70
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989



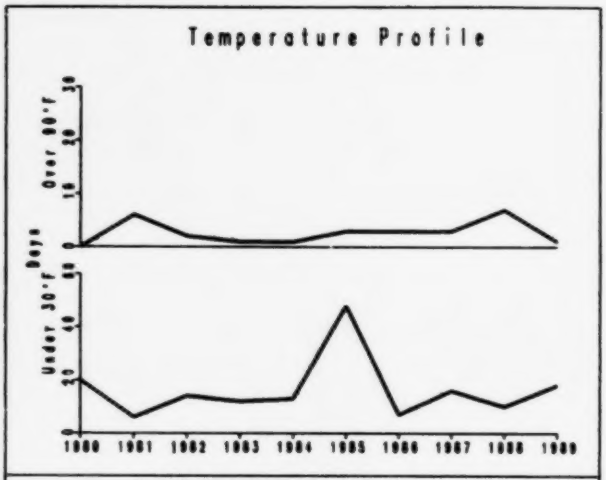
Number of Days in PSI Categories
Year
80
81
82
83
84
85
86
87
88
89
0
100
200
300
400
Days
Good
Moderate
Unhealthful
Very Unhealthful/Hazardous

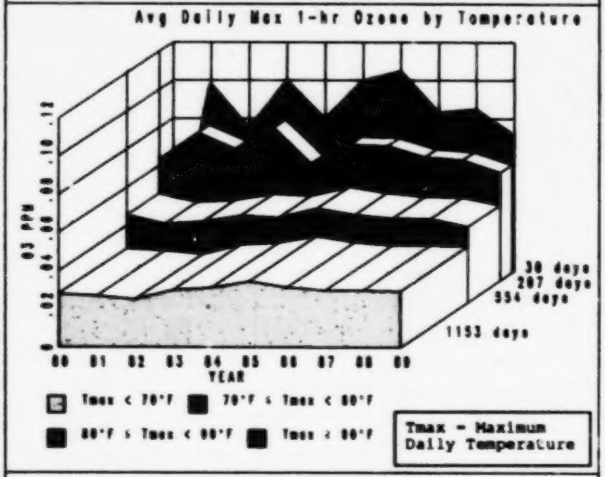
Seattle, WA

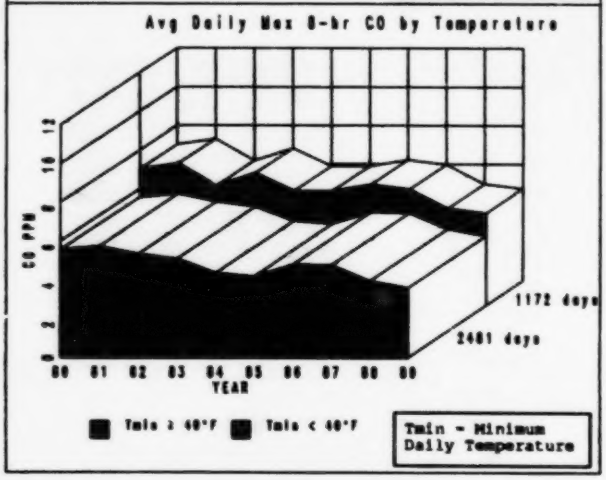
The Seattle PMSA consists of King and Snohomish Counties. Seventy-seven percent of it's population reside in King County. The estimated 1988 population was 1.9 million. Twenty-six currently active monitoring sites are shown on the map.

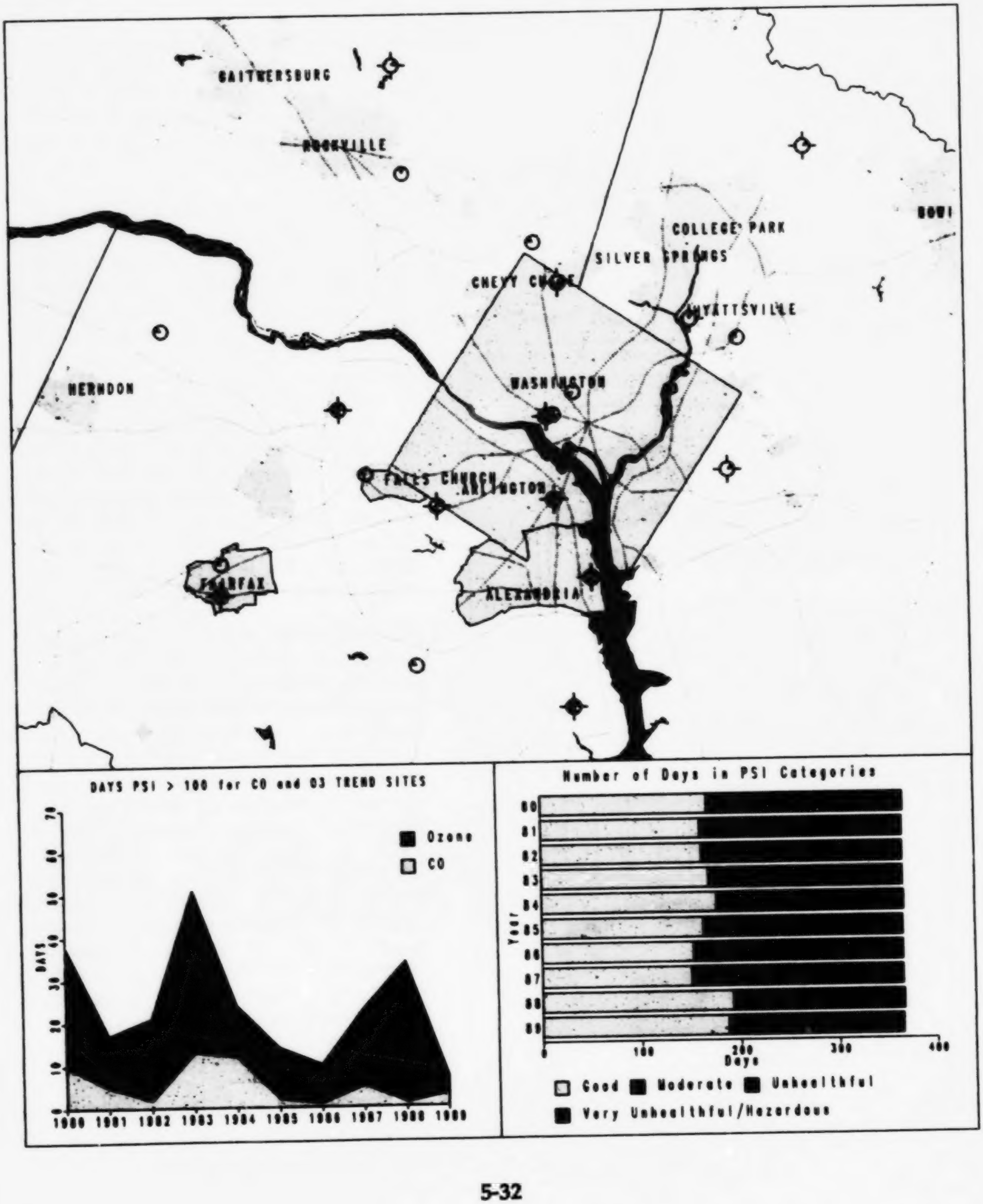
The PSI trend for Seattle is based on 7 sites: 6 CO and 1 for O_3, all located in King County. All six of the CO sites can be classified as maximum concentration sites.There are 2 maximum concentration CO sites and 4 population exposure sites. The O_3 site is a population exposure site. The number of PSI days > 100 are dominated by CO, where CO accounts for 175 (94%) of these days. There has been improvement in these days. Two of the 3 years with the smallest number occurred in 1988 and 1989. The percent of these days dropped from 9 percent in 1980 to 1 percent in 1989. The 2 very unhealthful days occurred in 1982. CO was responsible for both of these days.

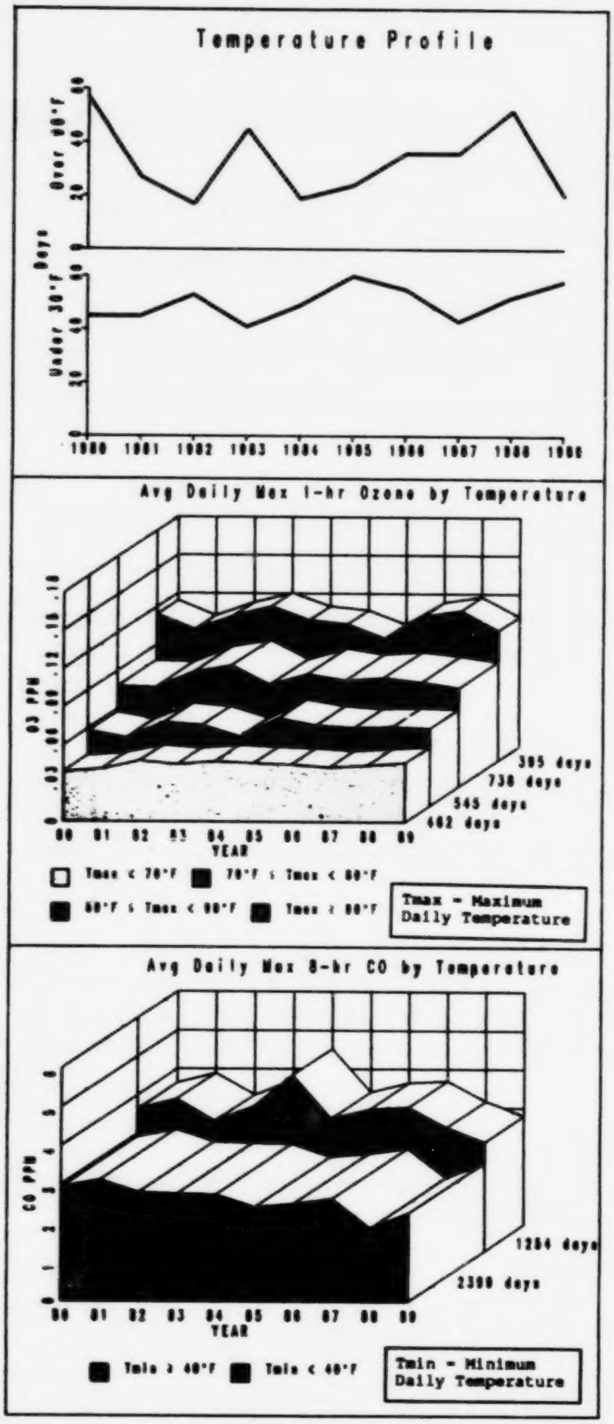
The average CO and O_3 concentrations by temperature follow the expected pattern, i.e. O_3 levels are highest on the hotter days and conversely CO levels are higher on the colder days. The number of 90° days with O_3 data is very small. Over the 10-year period, there doesn't appear to be much change in average O_3 levels for any temperature category. Average O_3, levels when all days are considered are essentially stable over the period only increasing slightly. On the other hand, average CO levels have declined. There were 35 and 32 percent reductions, respectively, in the ≥40° and <40° categories. There was a 34 percent improvement when all days were considered.








GAITHERSBURG
ROCKVILLE
BOWI
COLLEGE PARK
SILVER SPRINGS
CHEVY CHASE
HYATTSVILLE
HERNDON
WASHINGTON
FALLS CHURCH
ARLINGTON
FAIRFAX
ALEXANDRIA
DAYS PSI > 100 for CO and O3 TREND SITES
Ozone
CO
DAYS
0
10
20
30
40
50
60
70
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
Number of Days in PSI Categories
Year
80
81
82
83
84
85
86
87
88
89
0
100
200
300
400
Days
Good
Moderate
Unhealthful
Very Unhealthful/Hazardous



Washington, DC-MD-VA

The Washington PMSA consists of 10 counties, the District of Columbia (DC), and 5 independent cities. The principal population centers are DC, Fairfax County in Virginia, and Montgomery and Prince Georges Counties in Maryland. The estimated 1988 population was 3.7 million. Its size and location as a part of the eastern seaboard megalopolis contribute to the area's air pollution potential. The map shows 24 currently active monitoring sites.

The Washington PSI trend is based on data from 12 sites: 1 CO, 4 O_3 and 7 where both pollutants are monitored. All of the CO and all but one of the O_3 sites are population exposure oriented. The maximum concentration O_3 site is located in Prince Georges County. The trend of days with PSI > 100 varies partly with the days above 90°, shown in the temperature profile. This is seen both in the PSI bar chart and in the PSI > 100 plot. The effect of the very hot 1983 and 1988 summers is seen on O_3 levels. Seventy-seven percent of the PSI days > 100 are due to O_3. In 1989, there were 7 unhealthful days. In the 10-year period, 6 days fell in the very unhealthful category; the last occurred in 1987.

The temperature profiles show that O_3 levels are higher on hotter days while CO levels are higher on colder days. Average O_3 levels within a temperature category do not vary much. The 2 hottest categories show the impact of the 1983 and 1988 summers. When data from all days are used, 1989 daily maximum average O_3 is the lowest in 10 years; it is 12 percent lower than 1988 and 13 percent lower than 1980. Average CO levels declined in both temperature categories. The reason for the 1984 peak in days less than 40° is unclear, although a peak is observed at most sites for this year. High CO levels in 1984 also produced the largest number of NAAQS exceedances. Considering all days, daily maximum 8-hour average CO declined 22 percent.

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16. ABSTRACT

This report presents national and regional trends in air quality from 1980 through 1989 for total suspended particulate, sulfur dioxide, carbon monoxide, nitrogen dioxide, ozone and lead. Air quality trends are also presented for 14 metropolitan areas. Both national and regional trends in each of these pollutants are examined. National air quality trends are also presented for both the National Air Monitoring Sites (NAMS) and other site categories. In addition to ambient air quality, trends are also presented for annual nationwide emissions. These emissions are estimated using the best available engineering calculations; the ambient levels presented are averages of direct measurements.

This report also includes a section, Air Quality Levels in Metropolitan Statistical Areas (MSAs). Its purpose is to provide interested members of the air pollution control community, the private sector and the general public with greatly simplified air pollution information. Air quality statistics are presented for each of the pollutants for all MSAs with data in 1989.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Air Pollution Trends Emission Trends Carbon Monoxide Nitrogen Dioxide Ozone Sulfur Dioxide Total Suspended Particulates Lead Air Pollution Metropolitan Statistical Area (MSA) Air Quality Standards National Air Monitoring Stations (NAMS)		

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